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HANDBOOK

OF

ECONOMIC ENTOMOLOGY

FOR

SOUTH INDIA

BY

T. V. RAMAKRISHNA AYYAR, B.A., PH.D.
GOVERNMENT ENTOMOLOGIST, MADRAS (Retired)

Formerly Fellow of the Zoological and Entomological Societies of London—for sometime elected Member of the Senate, the Academic Council and of the Boards of Studies in Zoology and Agriculture of the Madras University and Examiner in Agricultural Zoology for the Madras, Bombay, Travancore, Nagpur and Punjab Universities,

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FOREWARD

Subsequent to the first publication of the book in 1940 great progress had been made in the field of economic entomology with special reference to the control of insect pests. With this aspect in view, the book has been revised by the author late Dr. T.V.R. Ayyar in 1950. In the revised edition, in addition to minor changes, information on records of new pests and also new insecticides have been included. However more recent developments in the evolution and use of new synthetic insecticides such as organo-phosphorous compounds, systemic insecticides etc., could not be included in the book as these developments have taken place after the revision of the book by the author. It is hoped that the revised edition will satisfy the long felt need for a standard book both for students as well as the workers in the field of Entomology.

ENTOMOLOGIST AND ASSOCIATE
PROFESSOR OF ENTOMOLOGY,
Agricultural College and Research Institute, Coimbatore.

PREFACE

THE FIRST book on the insects of this Province ("SOME SOUTH INDIAN INSECTS") was published in 1914 by Mr. T. B. Fletcher who was Madras Government Entomologist during 1912–1914, and Imperial Entomologist, Pusa, until recently. As the pioneer work on the subject, Fletcher's book will always remain a landmark in South Indian Entomology: but since this book is not available at present, being out of print, and our knowledge of South Indian insects has progressed by leaps and bounds since 1914, there has been a growing demand, especially from agricultural students and educated farmers, for a handy, up-to-date volume on South Indian Insects—especially insects having some economic importance. The present work is a modest attempt at meeting such a demand.

The plan of this work and the matter included therein form but an elaboration of the syllabus of the College lectures on Entomology which were given by the author to the students of the Madras Agricultural College for over twenty years since the opening of that institution at Coimbatore in 1908. However, the compiling and writing up of those lecture notes into a connected handy volume like this has consumed the whole of the leisure hours and holidays of the author during the years 1933 and 1934, without prejudice to his various duties as Government Entomologist, Madras, during that period. A considerable amount of attention has been paid to present the information in the book as up to date as possible, and at the same time to eliminate elaborate structural and other details which might affect the limited space in a handy volume like this, and which might not also be quite essential in a manual of this nature, chiefly intended for agricultural students and farmers. As is evident, the matter in the book is divided into two parts—one, a general part of six chapters, briefly giving some fundamental ideas of insects in general and their various activities, and the other a special part including general discussions on insect pests

as a whole, some of the control measures against them, and a brief annotated conspectus of the important insects of economic importance so far recorded from South India on different crops. A few appendices are also added to supplement the matter in the text, such as Insect Classification, Crop Pest Classification, Control Methods Formulæ and Bibliography. It is hoped that the general part will be found not only useful to the beginner in Entomology and the farmer in giving some general ideas on insects, but might also serve as a helpful introduction to Part II on Economic Entomology. Though the work is mainly based on South Indian insects, the author believes that it might also be of help to some extent to students and farmers in the other Provinces also, where some of the important economic insects are similar to those found in South India.

As is inevitable in the preparation of a work of this nature, which is practically a general text-book on the different aspects of the subject, the writer has drawn inspiration from various sources to supplement the information already available, and he has tried his best to indicate such sources also. With regard to the matter in Part II, he has utilized, wherever necessary, items of information from the many previously published papers on the Economic Entomology of South India, and especially from those contributed by the author himself and his co-workers in the Madras Agricultural Department for over two decades in the past. A list of the more important of such papers included in Appendix E might give some idea of the work done so far on the subject in South India.

It may be generally admitted, that in a publication of this nature, illustrations in many cases will be far more telling and effective than a torrent of the most carefully selected adjectives in the text description. Miss Ormerod, the Pioneer Agricultural Entomologist of England, wrote as early as 1885 thus: "I may most truly say that, if the crop or timber or fruit growers of India were furnished with plain and comprehensive accounts of the history and habits of the common insect pests, accompanied by woodcut figures, so as to convey the appearance of pests without

wearisome description of details, all this would be a national benefit, repaying the outlay a hundred times". With this important statement in view, attempts have been made to illustrate the text with, as many diagrams and figures as possible. This was possible without any great extra cost because most of the blocks prepared for Fletcher's book in 1914 and many others prepared now and then for illustrating previously published departmental bulletins, leaflets, year-books, etc., were available for use. In addition to this, the Imperial Council of Agricultural Research, Delhi, generously loaned for use 53 blocks previously made by the Imperial Department of Agriculture to illustrate papers and books published under their auspices; of these 53 blocks, including the one for the frontispiece of this book, 39 were, however, made for diagrams and drawings submitted by the author of this book to illustrate his papers published by the Imperial Department of Agriculture in previous years. A few of the other illustrations are from the author's own blocks made previously to illustrate his papers in the Madras Agricultural Journal. In addition to these, a few blocks have specially been made to reproduce some recent drawings and photographs got prepared by the author. As far as possible, the source of every previously published illustration reproduced in this work has been indicated under each.

With all the inevitable drawbacks and defects such a work as this is bound to possess, the author has ventured to present the same to those interested in the subject. If this present work has any value, it is largely due to the basis supplied by previous workers on South Indian Insects. The author is also fully aware of the fact that further studies and investigations on insects in South India and elsewhere are very likely to supplement, modify or correct many a statement in this book, and easily make it out of date and capable of revision, or even replacement. Until then, it is believed that this book might serve to some extent the purpose for which it is prepared and issued. The author will greatly appreciate and feel thankful if his attention is directed by readers to any errors in the book.

Before concluding this preface, the author takes this opportunity of expressing his grateful thanks to all those officers, co-workers and associates who have rendered him help in various ways to get the book published. To the Director of Agriculture, Madras, the author is greatly indebted for affording the opportunity for hastening the compilation of this book, getting it published under Government auspices and thereby allowing him to leave this handbook as a humble token of his long connexion with the Madras Agricultural Department. To the Imperial Council of Agricultural Research, Delhi, the author is specially thankful for the generous loan of the illustration blocks received through the Director of the Imperial Agricultural Research Institute and the Manager of the Government of India Press. The author is also indebted to the Government Entomologist, Coimbatore, and his staff for affording help in various ways to expedite the work; he is specially indebted to the artists for the diagrams and photographs prepared for him. Last but not least, he is under very great obligation to the Superintendent, Government Press, Madras, for the neat printing, for the preparation of many illustration blocks, for several valuable suggestions and ideas and for the excellent get-up of the volume.

February 1938. T.V.R.

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HANDBOOK OF ECONOMIC ENTOMOLOGY FOR SOUTH INDIA

PART I

GENERAL ENTOMOLOGY

CHAPTER I

Introduction to Entomology

Definition and scope of Entomology—Its relation to other Biological Sciences—Scope of Biological Science—Position of insects in the Animal kingdom and their nearest allies—Importance of insect knowledge.

The study of insects in their various aspects is known as the science of Entomology (Gk. *entomon*—insect and *logos*—discourse). In order to get some clear ideas as to what insects are, to find out their proper place in nature and to recognize the important relations and differences which exist between them and the various other organisms around them, it will be advantageous to have at least some very brief conceptions regarding the inter-relations of living beings in general and the different branches of the science which concerns them. The term *Biology* (*bios*—life) is applied to the subject dealing with all living beings ; this large and comprehensive science includes the study of two big groups into which all living things are divided—one which treats of all the plants of the world known as *Botany* (Gk. *botane*—a plant) and the other which deals with all the animals—called *Zoology* (Gk. *zoon*—an animal). While Botany and Zoology are sciences which deal with the vegetable and animal kingdoms as a whole, the studies of the various special groups of plants and animals are also known by convenient names and form branches of these two main trunks of Biology. Thus the study of birds is known as *Ornithology*, of worms *Helminthology*, of fishes *Ichthyology*, of fungi *Mycology*, of fruits *Pomology* and so on ; and similarly *Entomology* forms the study of insects.

Whichever the group of plants or animals one attempts to study, the following are some of the important aspects in which such studies can be conveniently made, since these include almost the entire scope of all biological investigations. Though the aspects here shown are Zoological, they apply equally to Botanical studies also.

Different Aspects of Zoological Study.

I. Morphology.

The study of the form and structure of the bodies of animals in their different stages. This includes Anatomy, Histology, Cytology and Embryology.

II. Physiology.

The study of the functions of the different parts of an animal separately and in relation to the organism as a whole, with the processes of feeding, waste, repair, reproduction, etc.; studies on the Physics and Chemistry of Protoplasm may also be included here.

III. Evolution.

The study of the process which has brought about the great variety and wealth of animals and their distribution in time and space includes Zoogeography, Palæontology and Genetics.

IV. Taxonomy.

Classification of animals (Systematic Zoology).

V. Ecology.

The study of the realations of animals to their environments both living and non-living, and the various adjustments.

Though the main theme of this handbook is the study of insects from their economic point of view it is believed that some general ideas regarding insects in relation to the different aspects noted above will be of considerable advantage to the economic entomologist. The first few chapters of this book are, therefore, devoted to a very brief consideration of these general aspects chiefly in connexion with insects.

Position of Insects in the Animal Kingdom and their nearest Allies.

All the animals inhabiting our world are generally classified by laymen into lower and higher animals and by scientists into ten or twelve fundamental divisions called Phyla or sub-kingdoms, each phylum including a group of animals which possess certain important structural characteristics in common. One of the most important of these main divisions is the phylum *Chordata* which includes all the higher animals popularly known as *Vertebrata* (animals with a back bone) such as mammals, birds, reptiles, frogs and fishes. The other phyla include the multitudes of lower animals known together as lower animals or *Invertebrata* (animals without a back bone). More important among these latter are the *Protozoa*

including the minute one-celled animals, some groups of worms such as Flat worms, Round worms, Segmented worms, etc., the *Echinodermata* constituting marine forms like sea stars, sea urchins, etc., the *Mollusca*, comprising shell fish, cuttle fish, snails, slugs, etc., and the *Arthropoda* to which insects and their allies belong. The phylum Arthropoda is the largest of all in the animal kingdom, and since it includes the group of insects the fundamental characteristics of this big division will be useful in understanding the correct position of insects among various animals.

IMPORTANT GROUPS OF ANIMALS.

ANIMAL KINGDOM (*divided into Phyla*).	—*Phylum*	PROTOZOA.	*One-celled animals.*	LOWER ANIMALS (*Invertebrata*).
	—*Phylum*	PORIFERA.	*Sponges.*	
	—*Phylum*	COELENTERATA.	*Jelly-fish, corals, etc.*	
	—*Phylum*	ECHINODERMATA.	*Star-fish, sea urchins, etc.*	
	—*Phylum*	PLATYHELMINTHES.	*Flukes, tapeworms, etc.*	
	—*Phylum*	NEMATHELMINTHES.	*Roundworms, eel-worms, etc.*	
	—*Phylum*	ANNULATA.	*Earthworm, leech, etc.*	
	—*Phylum*	MOLLUSCA.	*Snails, oysters, slugs, etc.*	
	—*Phylum*	ARTHROPODA.	(See *below*).	
	—*Phylum*	CHORDATA.		HIGHER ANIMALS (*Vertebrata*).

Main divisions of the Phylum.

ARTHROPODA

Classes.

ONYCHOPHORA (*Peripatus*).	CRUSTACEA (*Crabs, Prawns, etc.*).	INSECTA.	ARACHNIDA (*Spiders, Scorpions, etc.*).	MYRIAPODA (*Centipede, Millipede*).

ARTHROPODA.

The numerous forms included in this phylum are all bilaterally symmetrical animals, the right and the left sides of the body corresponding in structure and having the mouth and the anus at the anterior and posterior extremities. The body is made up of a series of ringlike divisions or segments lineally arranged one behind the other as in the segmented worms. In these features the Arthropoda resemble the segmented worms like earthworms and leeches and on that account the Arthropoda are believed to have descended from

ancestors like segmented worms. But unlike as in the segmented worms, the body segments in many of the arthropoda are generally found grouped into two or three regions of the body and some or all the body segments bear paired appendages or limbs which are jointed or made up of pieces—hence the name Arthropoda (jointed legs). The body surface is covered by an external skeleton made up of a substance called "*Chitin*". Though all the Arthropoda possess these fundamental similarities we still find some well-marked differences among the members of this great group, and according to those differences the phylum is subdivided again into five important subdivisions or classes known as *Onychophora, Crustacea, Arachnida, Myriapoda* and *Insecta*. Thus, we find that the group Insecta forms one of the five important classes in the sub-kingdom Arthropoda. Before commencing the study of insects it will help us to get some ideas of the more important and distinguishing characters of the four other classes of animals mentioned above which are the close allies of insects; for, such a knowledge will be useful in correctly identifying an Arthropod and avoid mistaking members of the closely allied groups for insects and *vice versa*.

ONYCHOPHORA.—This class includes the primitive soft worm like terrestrial creature known as *Peripatus* [fig. 1 (*a*)]. It has certain peculiar characters which appear to connect the Arthropoda with the segmented worms. The body is worm-like and though not segmented has many unjointed legs. It has one pair of feelers at the anterior end and the body is not distinctly divided into regions. It breathes air and there are both tracheal vessels and *nephridia* (excretory organs of worms) present. The creature, though rare, has been found in different parts of the tropics.

ONYCHOPHORA

FIG. 1 (*a*).—PERIPATUS.

[*After Balfour*]

CRUSTACEA [*fig.* 1 (*b*)].—Among the more familiar forms belonging to this class of animals are the crabs, prawns, lobsters, barnacles, etc., which are mostly aquatic animals. In most members of this group the body segments are generally grouped into two distinct regions, the *Cephalothorax* (head and thorax) and the *Abdomen*; the head bears two pairs of feelers, the thorax at least five pairs of locomotary limbs and the creatures breath by means of gills. In this class are also included the small many-legged

creatures called "*Wood lice*" which are land forms and generally found in moist situations in houses and godowns. These have the habit of rolling themselves into a ball when disturbed and are often mistaken for insects.

CRUSTACEA

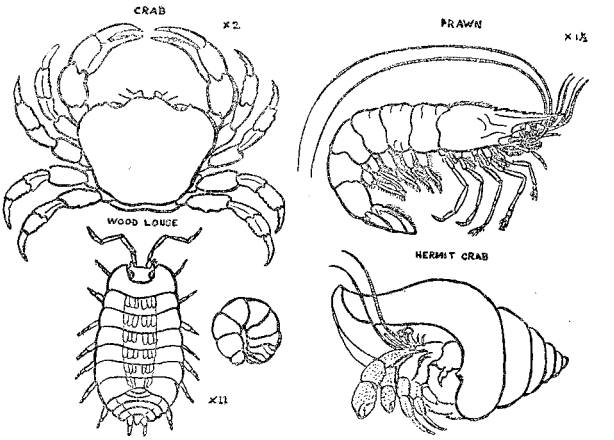


FIG. 1 (*b*).—EXAMPLES OF CRUSTACEA.

ARACHNIDA [*fig.* 1 (*c*)].—This class includes scorpions, spiders ticks and mites. All these are land forms and air breathers with no gills like the Crustacea. They possess four pairs of legs and the head bears simple eyes and no antennæ ; in place of antennæ

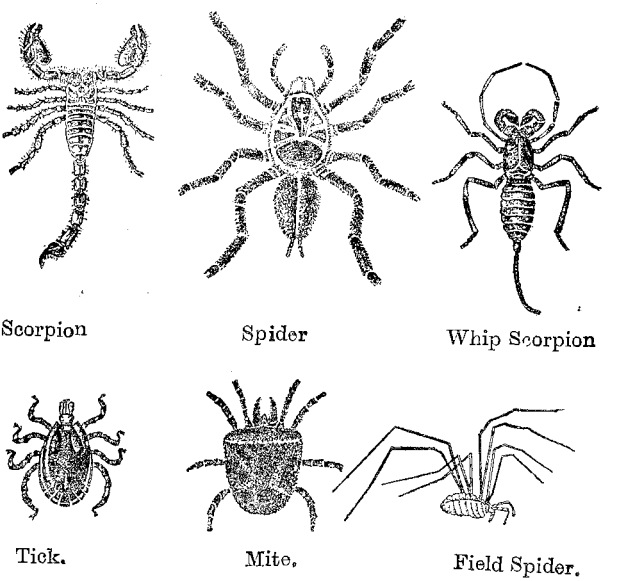
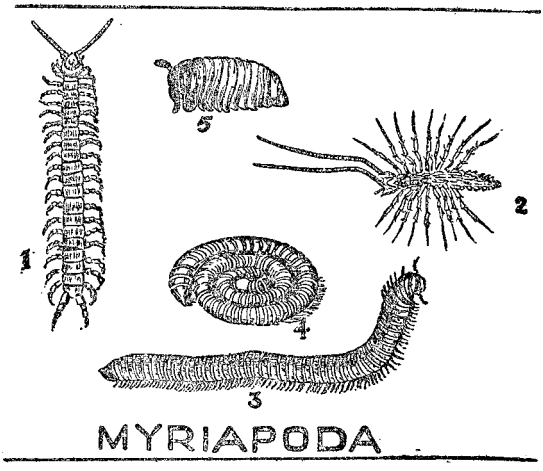


FIG. 1 (*c*).—SOME COMMON ARACHNIDA

and mandibles we find two structures known as *chelicerœ* and *pedipalpi*; the body is divided either into two divisions as in the Crustacea or all the body segments are found fused together into one compact piece. Spiders and scorpions are carnivorous, ticks and many mites are found as ectoparasites on higher animals and some mites are plant feeders often causing damage to some cultivated crops. The smaller forms of this class are often mistaken for insects.

MYRIAPODA [*fig.* 1 (*d*)].—The well-known creatures named as centipedes and millipedes come under this class. In these, the body is elongated and only two regions can be distinctly recognized, viz., the head and the elongated many segmented trunk behind it. The former bears one pair of feelers and the eyes are groups of ocelli (simple eyes). Each of the body segments bears one or two pairs



[*After sharp.*]

FIG. 1 (*d*).—EXAMPLES OF MYRIAPODA.

1. Centipede.
2. Scutigera.
3 & 4. Millipedes.
5 Pill millipede.

of limbs (one in the centipedes and two in the millipedes). These are air breathers and found in moist situations and often near dwellings; the centipedes are carnivorous and poisonous while most of the millipedes are vegetarian in habits and a few of them occasionally cause damage to underground parts of some cultivated plants. Millipedes have the characteristic habit of curling themselves into a coil or a ball when disturbed; those with the latter habit are known as "*Pill millipedes*",

INSECTA [*fig.* 2] [Lat. *insectum = cut into or segmented*].—Members of this class can be separated from those of the previously noted groups by several well-marked characters; the most important of these are (*a*) the division of the body into three distinct regions (head, thorax and abdomen), (*b*) the possesion of three pairs of legs, and (*c*) the presence of wings in almost all adults. Though there are several other important structural features characteristic of this

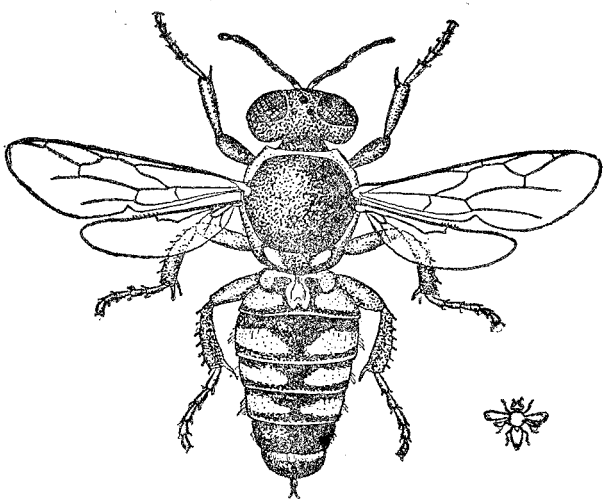


FIG. 2—TYPICAL INSECT SHOWING THE MOST IMPORTANT FEATURES.

(Wasp-*Oxybelus squamosus*, S.)

(*From S.S.I.*)*

very large class of animals, which we shall note in the following pages, these three important characters alone will be quite sufficient to distinguish an insect from all other Arthropoda; in fact, the possession of six legs alone is a fundamental hall mark of all insects and the group on that account is also known as *Hexapoda* (six-legged forms). This class includes the highest organized forms among the Arthropoda.

* Some South Indian Insects, 1914.

Important characters of the chief Arthropod divisions.

Class.	Antenna or feeler.	Legs.	Body divisions.	Eyes.	Remarks.
1 ONYCHOPHORA (Peripatus).	One pair ..	Many pairs of unjointed legs.	No clear divisions ..	Two simple eyes ..	Aberrant lowly organized group with characters connecting segmented worms and Arthropoda. Possesses both nephridia and tracheal vessels.
2 CRUSTACEA (Crabs. Prawns; Wood lice, etc.).	Two pairs ..	Many or at least five pairs.	Two—Cephalothorax and Abdomen.	Compound eyes (often stalked).	Mostly aquatic forms with gills.
3 ARACHNIDA (Scorpions, Spiders, Mites and Ticks).	No antenna ..	Four pairs only ..	Two (Cephalothorax and Abdomen) or no divisions.	Simple eyes ..	Land forms with lung like structures for breathing. Chiefly carnivorous; some plant feeding.
4 MYRIAPODA (Centipedes and Milli pedes).	One pair ..	Numerous—one or two pairs to each segment.	Two (head and the long trunk).	Simple eyes or clusters of simple eyes.	Worm-like long forms. Land animals.
5 INSECTA (Insects)	Do. ..	Only three pairs ..	Three distinct regions (Head, Thorax and Abdomen).	Compound eyes and very often simple eyes also.	Wings present in most adults. Air breathers. Found chiefly on land though some are aquatic.

Importance of Insect knowledge.

Apart from the numerous characters of purely scientific interest which insects possess in a remarkable degree in their general organisation and habits as compared with other animals, they form a group of very great importance in various other ways. In their numerical strength they outnumber all the other groups of land animals put together and in their intimate relations with man in diverse ways, they occupy a position far more conspicuous and important than most other groups of animals. The damage that some of them cause to field crops, orchards, stored products and household materials, and the part that some of them have recently been found to play in interfering with man's health and conveniences as household pests, are matters of no small importance; nor can we overlook the other side of the picture, viz., the value of some insects to man in various ways as suppliers of useful products like silk, honey, lac, etc., and as man's friends in checking injurious insects in the form of scavengers, parasites and predators. In the words of Rev. J. G. Wood: "The study of Entomology is one of the most fascinating of pursuits. It takes its votaries into the treasure houses of nature and explains some of the wonderful series of links which form the great chain of creation. It lays open before us another world of which we have been hitherto unconscious, and shows us that the tiniest insect, so small perhaps that the unaided eye can scarcely see it, has its work to do in this world and does it." A knowledge of insects and their general habits, therefore, will not only help man to devise ways and means to fight his pests properly but would also give him the directions to take advantage of the products of useful forms and the helpful activities of friendly insects. Such a knowledge is evidently not only important but a necessity, especially in the case of many of us who take to agricultural practices. This may be realized from a study of the following chapters which are mainly intended to deal with the subject of Entomology in its various relations to man, especially the South Indian farmer.

CHAPTER II.

External Organization of Insects.

Body representation and protection—The three regions of the body—General structural features of each region.

In every insect the body is composed of a series of somites or segments connected together one behind the other as in the segmented worms, the arrangement being known as metameric segmentation. The external surface of the body or the *cuticle* in the adult insect forms a hard covering composed of a material called *Chitin*, which the lower or endodermal layers of the body-wall produce. This chitinous layer which covers the entire surface of the body is not, however, of the same hardness and consistency all over the body of the insect; to allow it to conveniently move its limbs and some other organs, this covering remains soft and flexible at the different connexions and joints; the younger stages of most insects, however have the body surface generally soft and not developed into a hard covering. The chitinous integument is, in some regions of the insect's body pushed inwards and forms a sort of internal frame work known as the *endoskeleton* to which are attached the important muscles of the different regions. In the absence of a bony internal skeleton as in the higher animals (fig. 3), this chitinous exoskeleton together with the specialized endoskeletal parts of the body wall acts as a strong support as an outer protection and inner attachment to the soft internal organs of the insect. In some of the typical segments of the insect body this skeletal integument is made up of atleast four hard regions (*sclerites*) the dorsal *notum* or *tergum*, the ventral *sternum* and the two lateral *pleurae* which are all connected in such a way as to serve both for body protection and for convenient movements. While it is possible to make out these distinct areas only in a few cases, this exoskeleton in most of the body segments is fused together and also differentiated in various ways, so that it will be very difficult to make out the divisions clearly. The external body surface also bears very often outgrowths like hairs, setæ, spurs, spines, scales, etc., of various kinds in different insects performing different functions.

The Regions of the Insect Body.

Though the fundamental build of the body is in the form of a chain of segments with jointed appendages as in other arthropods, in the insect body the segments are generally grouped into three well defined regions, the *Head*, the *Thorax*, and the *Abdomen*, each region possessing the respective organs for performing the different vital functions of the insect such as feeding, locomotion, respiration, reproduction, etc.; the lateral appendages are also considerably reduced in number compared to other arthropods (fig. 4). Generally the number of visible or clearly defined segments in any adult insect

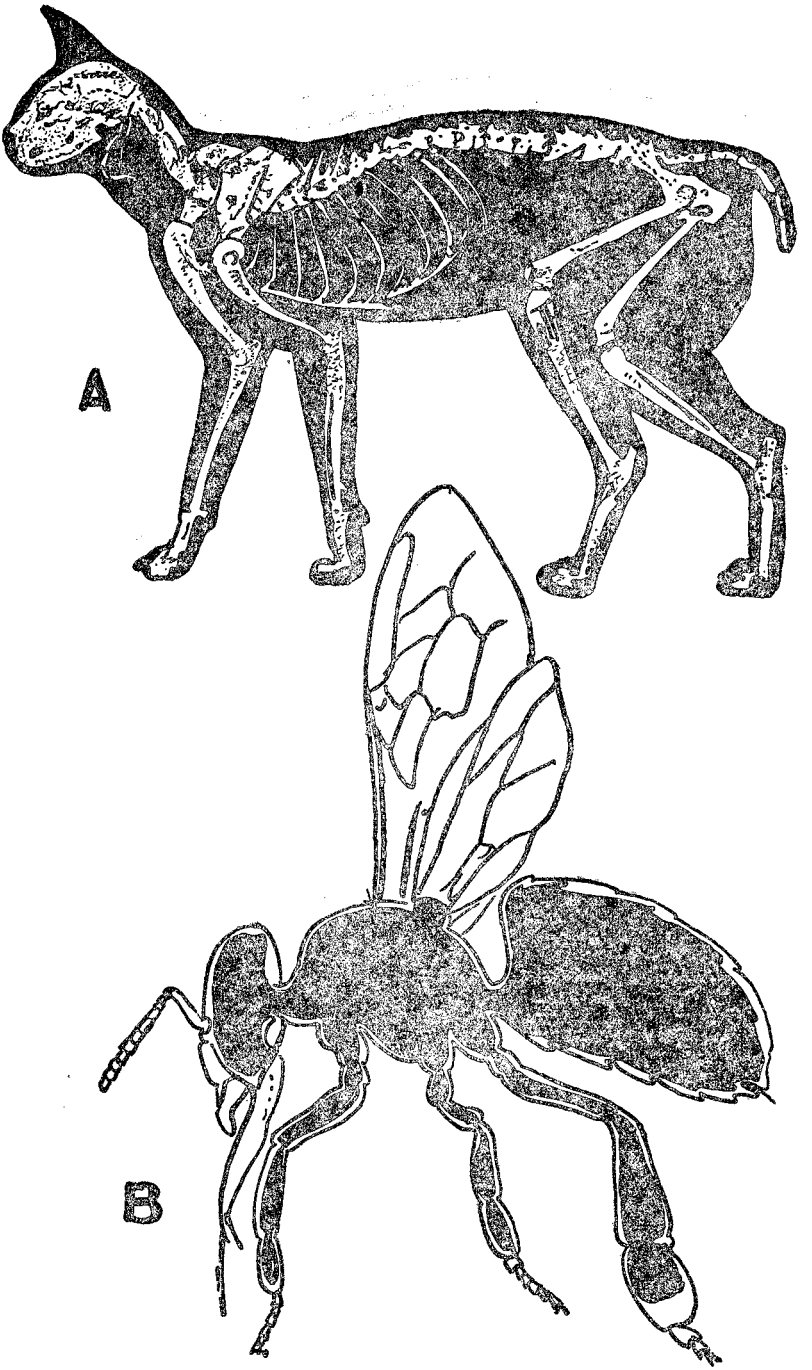


FIG. 3.—SKELETON OF (A) CAT AND (B) BEE.
(To show internal bony skeleton of the former and the chitinous exoskeleton of the latter.)
[*From Metcalf and Flint.*]

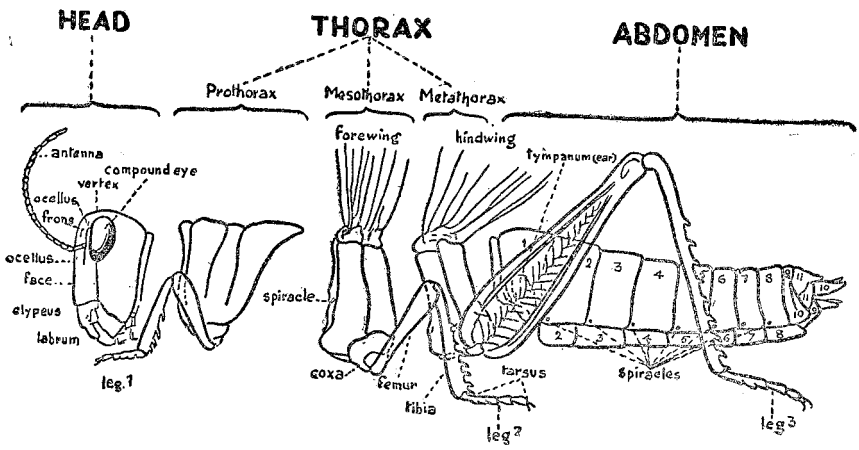


FIG. 4.—DIFFERENT REGIONS OF A TYPICAL INSECT (A GRASSHOPPER).

[*From Metcalf and Flint.*]

is not more than a dozen; but the studies on the development of insects go to show that the actual number of segments that make up the body of a typical insect is twenty (twenty-one according to some workers), and three main regions of the body are formed out of this number.

The Head.—Of the three regions, the head is generally the smallest. It is the anteriormost part and is connected behind with the thorax. Though in general form and shape it appears as a more or less single compact structure it is really composed of seven original body segments which have gradually become fused together in the course of the development of the insect as the head capsule (*cranium*). In typical insects the following definite areas could be made out on the head:—the dorsal region or top of the head, between the two eyes is the *Vertex*, and the area behind it connecting the head with the neck is the *Occiput*; this latter and the vertex together form the *Epicranial area*. The region just below and anterior to the vertex is the *Front* (or frons). Below the frontal region are two transverse pieces one above the other, the upper *Clypeus*, which is divided into two pieces in some forms and the lower *Labrum*; the cheeks or sides of the head and the space behind and beneath the eyes are formed of the *Genae* and the wall of the posterior region of head has often a piece called *Gula* conspicuous only in some forms.

The mouth opening is situated at the antero-ventral extremity of the head between the labrum above and the labium below; the head has either its long axis vertical with the mouth parts ventral (*Hypognathous*) as in grasshoppers or the long axis horizontal with the mouth parts antero-ventral (*Prognathous*) as in some beetles; in some bugs a third type where the mouth parts are postero-ventral also exists known as *Opisthognathous*. The important

structures found on the head are the *Eyes*, the *Antennae* or feelers and the group of appendages around the mouth called '*Mouth parts.*' (*See* figs. 4 and 8).

The Eyes (*fig.* 5).—Two kinds of eyes are met with among insects, the compound or facetted eye and the simple eye or *ocellus*. Each compound eye is practically a group of minute facetted structures (*ommatidia*) crowded together and functioning as a combined organ of vision; though they are not in any way homologous to the eyes of higher animals as organs of vision, among insects they are remarkably well constructed. The simple eye or ocellus is a very minute speck of pigmented shining surface or cornea and is believed to help the insect to distinguish light from darkness. In almost all adult insects one pair of compound eyes and one or more ocelli are present; the former are quite conspicuous on the heads of most insects. While typical compound eyes are generally met with only in adult insects, ocelli are found both in the adult and many larval forms. In the case of adult insects one to three ocelli are found situated on the dorsal surface of the head generally between the two compound eyes; though many larvæ have no visual organs, in those possessing them the ocelli are generally arranged along the lateral margins of the head and these *lateral ocelli* are in many cases different in some features from the *dorsal ocelli* found in adult insects. In shape, position, size and structural peculiarities the

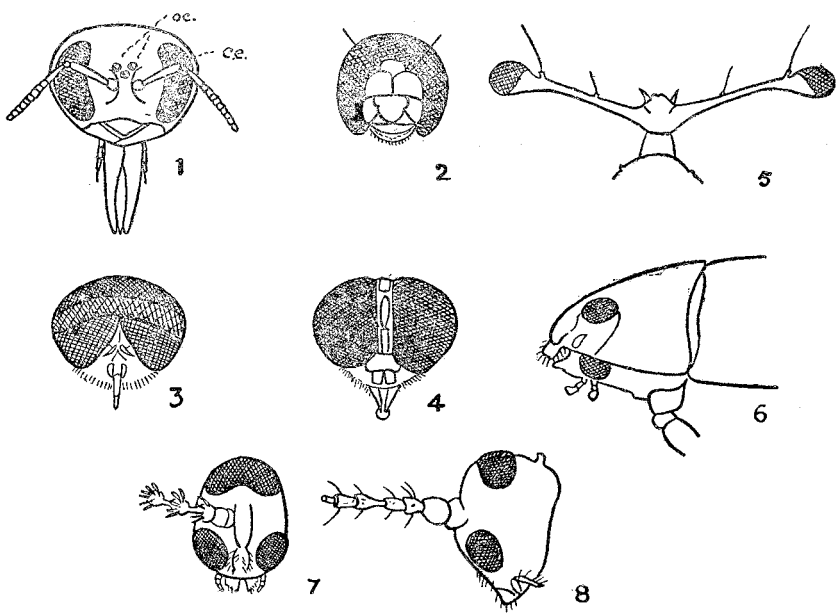


FIG. 5.—EYES IN INSECTS.

1 Carpenter bee.
2 Dragon fly.
3 & 4 Male and female gad fly.
5 Diopsid fly, stalked eyes.
6 Water beetle (*Gyrinid*).
7 & 8 Gall fly (*Cecidomyid*).

[*From S.S.I.*]

paired compound eyes exhibit remarkable variations, and in some insects these organs have reached an extraordinary degree of perfection as organs of sight. In the males of some insects the two compound eyes are very large, practically occupying the greater portion of the head region and touching each other at the median line (*See* fig. 5–3).

The Antennae.—The head bears one pair of feelers or antennæ; these are organs attached to the front of the head between the two eyes or in front of them and they are never more than two in number and all typical insects possess them. Each antennæ is generally a slender movable whiplike structure made up of a number of pieces or joints showing in some cases differences in structure between the different joints also. The two antennæ are very sensitive in nature and are found to function chiefly as tactile and olfactory sense organs. As with the eyes, the form, shape and other peculiarities of the antennæ are very varied and many important types of these organs are recognized among insects such as setaceous, plumose, pectinate, serrate, clavate, etc.; even males and females show difference in antennal structure in many forms and these differences are of great taxonomic value (fig. 6).

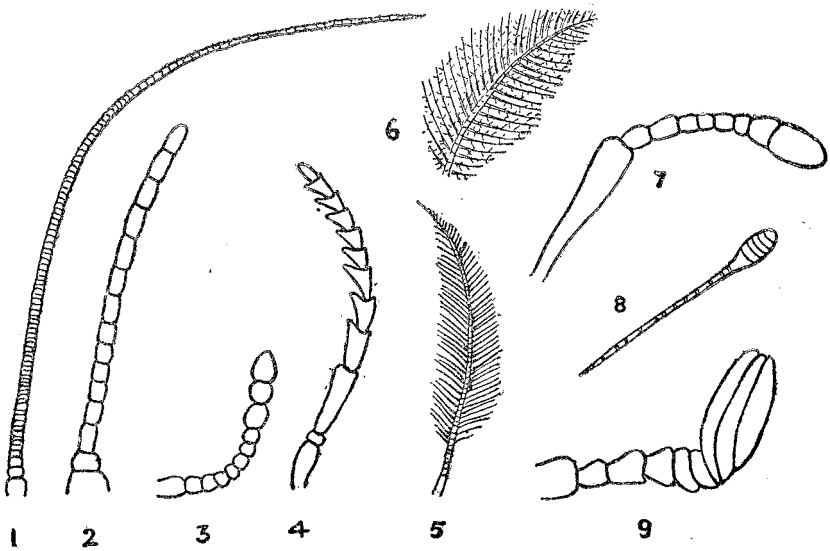


FIG. 6.—FEELERS IN INSECTS.

1 Cockroach (*Setaceous*).
2 Grasshopper (*Filiform*).
3 Brenthid (*Moniliform*).
4 Longicorn (*Serrate*).
5 Mantis (*Pectinate*).
6 Tussockmoth (*Plumose*).
7 Leafweevil (*Clavate*).
8 Butterfly (*Capitate*).
9 Dungroller (*Lamellate*).

[*From S.S.I.*]

The Mouth parts.—The appendages of the head situated around the mouth which help the insect in the act of feeding are together known as its "*Mouth parts*" *or* "*Trophi.*" Though a considerable

degree of variation is met with in the morphology, in the arrangement and in the specific functions of these structures, among different groups of insects, the various categories of mouth parts among

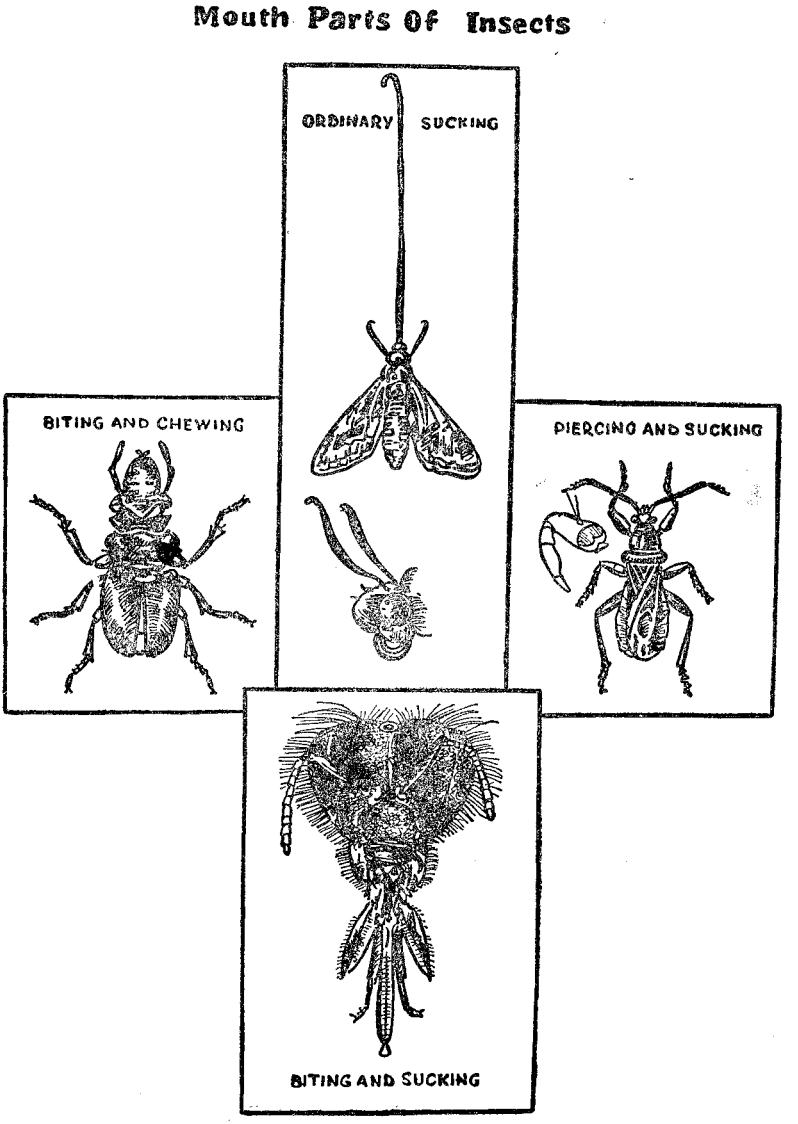


FIG. 7.—MOUTH PARTS OF INSECTS (different types).

them can be brought under two main types according to the manner in which different insects take their food. These two are the biting and chewing or *mandibulate* type and piercing and sucking or *haustellate* type (fig. 7). The former is found among those

insects which feed by mastication or chewing their food which generally consists of solid stuff; familiar examples of such insects are grasshoppers, beetles, and caterpillars. The sucking type, on the other hand is characteristic of those which generally take liquid nutrition by a process of sucking; common insects of this type are the plant bugs of various kinds, mosquitoes, the bed-bug, butterflies and blood sucking flies. Of these two distinct categories which are evidently adapted for two entirely different modes of feeding, the chewing type, as found in a grass hopper, is the more primitive one where all the different parts of the original paired appendages could be made out and their homologies traced; in the sucking type which is evidently one evolved from the mandibulate model, the different parts become considerably changed and it is found very difficult to understand the correct homologies of the different parts in some sucking insects. In a typical mandibulate form the following parts are present (fig. 8):—(1) The *labrum* or upper lip; this is

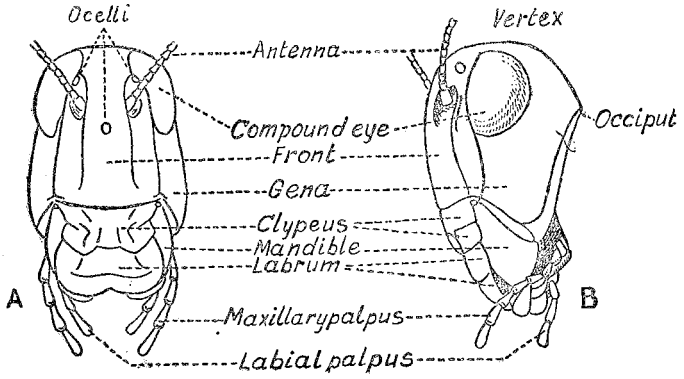


FIG. 8.—OUTLINE OF THE HEAD OF A GRASSHOPPER SHOWING REGIONS AND APPENDAGES—A. Front view. B. Side view.

an unpaired median plate attached to the clypeus and capable of movement. (2) One pair of *mandibles* or jaws—one on each lateral side of the head moving in a transverse plane. Each is generally a hard solid piece and, in some insects, it bears teeth. (3) The paired *maxillae* or the additional jaws; these are more complex in structure than the mandibles and each is made up of four or five separate pieces—two pieces basally and three distal lobes one of which is a many jointed palpus. (4) The *labium* or lower lip: this structure though found as a single piece is actually composed of a pair of embryonic appendages which have become fused along the median line and the labial appendages form the second maxillæ. The labium is attached to the head by a basal piece called mentum and bears on each side a palp similar to the one in the maxillæ. As noted before in some forms there is a sclerite called *Gula* forming

the ventral wall of the hind part of the head bearing the labium and the second maxilla. The three paired appendages form the actual mouth parts. In addition to these, is an unpaired tongue like median structure called the *Hypopharynx* attached to the inner surface of the labium. A corresponding median piece called the *Epipharynx* is found in some forms attached to the roof of the mouth below the labrum or clypeus. Among insects with suctorial mouth parts five different types could be made out—(*a*) the arrangements found in butterflies and moths where the sucking organ is a spiral tube kept rolled up under the head of the creature when the insect does not feed '*siphoning*' (fig. 7), (*b*) the kind found in most plant bugs, mosquitoes, biting flies, etc., where the organ is a long curved or foldable beak, sharp at the tip, '*piercing and sucking*' (*c*), the model found in insects like the house-fly where the organ is distally flattened '*sponging*', (*d*) in the group of insects including the bees and wasps (Hymenoptera) and in some Aptera we find a type of mouth parts where the mandibulate and suctorial arrangements are more or less combined into one to serve both the functions, '*chewing and lapping*', (*e*) a model intermediate between the chewing and piercing type found in *Thrips* '*rasping and sucking*'.

It has to be noted that the mouth parts among insects are of very great importance not only from a scientific or systematic point of view but also from the standpoint of the Economic Entomologist, since some of the control measures against insect pests depend a great deal on the nature of the mouth parts they possess; a knowledge, therefore of these structures will be of very great advantage. The following diagnostic plan of the different organs of the head will give one a clear idea of the arrangement in a typical insect.

Right compound eye	Vortex	*Left compound eye*
Right ocellus		Left ocellus
Right antenna	Median ocellus	*Left antenna*
	Frons	
Right gena	Clypeus	Left gena
	(Labrum)	
	(Epipharynx)	
(*Right mandible*)		(*Left mandible*)
	MOUTH	
(*Right maxilla*)		(*Left maxilla*)
	(Hypopharynx)	
	(*Labium*)	

[*From Metcalf and Flint*],

NOTE.—These in italics are homologous to appendages and those in parenthesis form the mouth parts.

The Thorax.—This is the second and middle region of the insect body; in front it is connected with the occipital region of the head by a flexible neck or cervical region and posteriorly it is attached to the base of the abdomen. This region is made up of three separate segments known as the pro, meso and meta thoracic segments (fig. 4). In some forms like the grass-hoppers, crickets, etc., the prothorax is shield-like and is often much bigger than the

hinder two segments; these latter are generally fused together and in many insects the chitinous exoskeleton of these segments is divided by sutures into different regions and structures in each generally known as *scutellum, post scutellum, etc.* The most important appendages of the thorax are the legs and the wings.

The Legs (*fig.* 9).—The presence of three pairs of legs in an insect is such a fundamental character that the simplest definition of

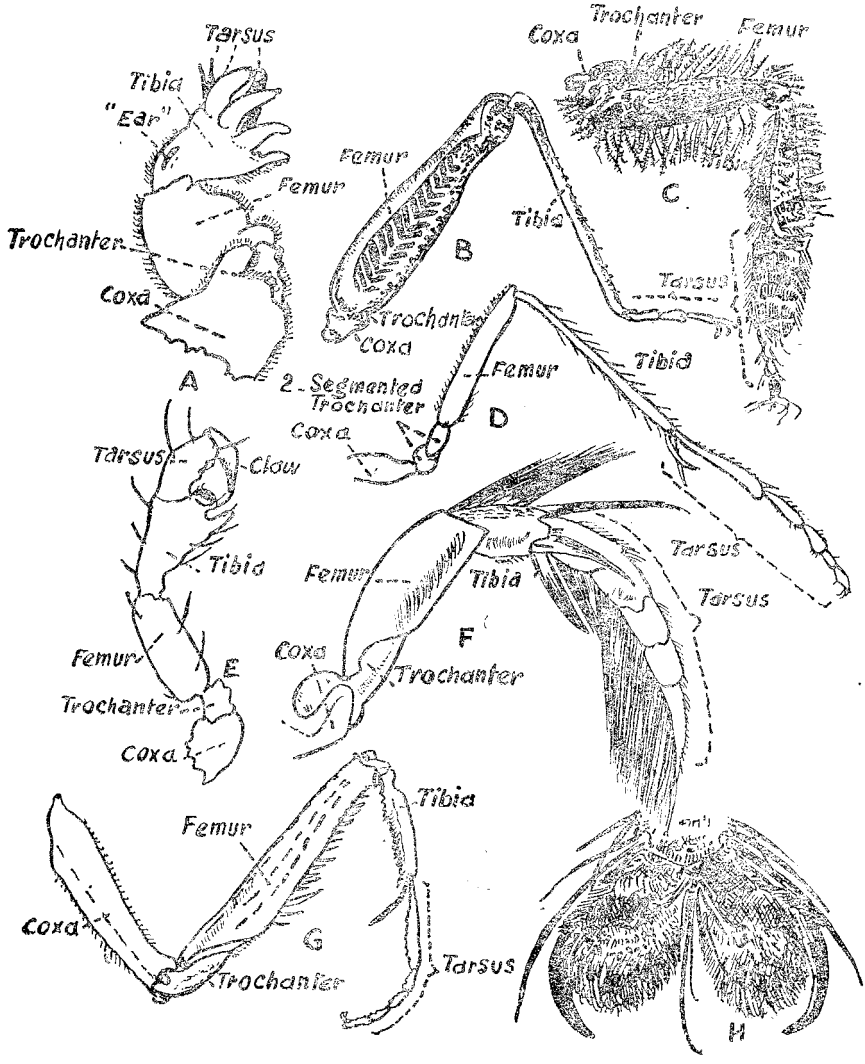


FIG. 9.—LEGS OF INSECTS.

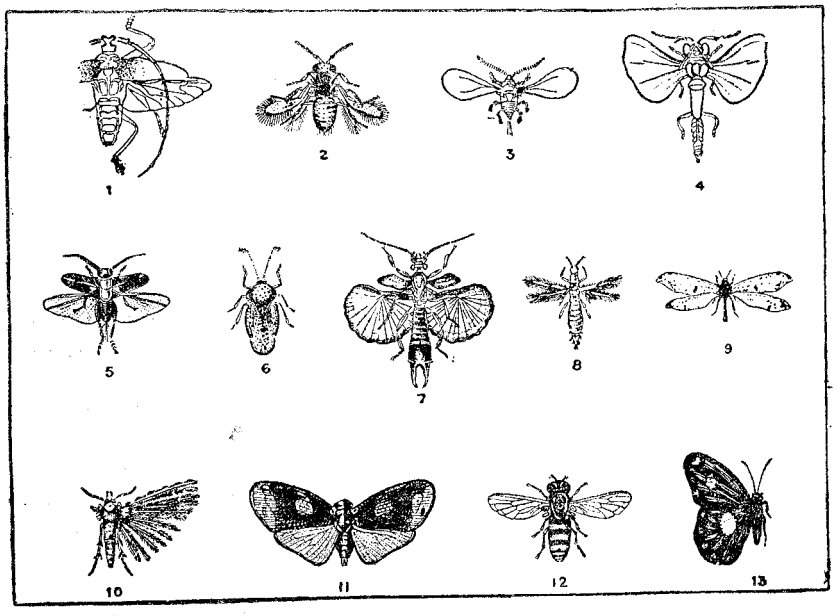
A Mole cricket (digging).
B Grass-hopper (jumping).
C Bee (pollen carrying).
D Wasp (walking).
E Louse (clinging).
F Water beetle (swimming).
G Mantis (grasping).
H Fly (enabling to walk upside down).

[*After Metcalf and Flint*]

an insect can be put down as "a six-legged arthropod." These legs are present in almost all adult insects though they may be absent in some larval forms. Each thoracic segment bears one pair of legs—one leg attached to each of its lateral sides. The legs are typical jointed limbs and are made up of distinct pieces articulated to each other by movable connexions. Though the size, shape, armature and other peculiarities in the structure of the legs show remarkable variations in different insects and are modified for various modes of life, in all of them each leg is made up of five distinct pieces, viz., the proximal *coxa*, the second *trochanter*, the third *femur*, the fourth *tibia* and the distal *tarsus*. While the coxa, femur and tibia are always single pieces, the trochanter and the tarsus are not always so; the former is found divided into two in some insects (chiefly parasitic Hymenoptera), and the tarsus is made up of a number of joints in most insects, the number of joints varying from one as in some primitive forms to five pieces which is more or less typical. The femur and tibia are genealy the longest of the joints. The tarsus is generally provided at its tip with a pair of horny claws and pads to help the creature in locomotion. Some of the leg joints, especially the tibia and the tarsus are often armed with spines and spurs, etc., of various shapes in many insects for defensive and offensive purposes. As stated above, the legs in insects are of various patterns and though primarily intended for locomotion they are adapted in many for various other functions. In some they serve as running, in some as swimming in others as hopping and in some others as digging and even as offensive organs (fig. 9). These structural variations offer very striking and important factors in the systematic classification of the different sub-division of insects.

The Wings.—Insects are the only creatures which possess wings among the lower animals (Invertebrata). These organs are thin expansions of the body integument and serve as organs of flight as in birds though in structure the wings of birds are of an entirely different pattern. Among insects wings are found only in the adult, and even among adults there are some primitive forms which are wingless (apterous) all their life. While the wingless condition is primary in some (Apterygota) in some others this condition is found due to variations or degeneration from the originally winged condition (as in some grass-hoppers, bugs, fleas ,wasps, etc.). Two pairs of wings are generally present, the front or upper pair attached to each side of the mesothorax and the hinder or lower pair connected to the sides of the metathorax; the prothorax never bears wings. When only one pair is present it is always the first pair; thus all the locomotary organs are borne by the thorax. The two wings on each side are sometimes held together by an apparatus called *frenulum* (as in many lepidoptera). In the group of flies and in the males of some bugs, only the front pair is developed, the other one being considerably reduced or absent. In flies, the reduced hind wings are known as "*halteres*," or balancers. The males of the strepsiptera (Stylops) are unique in having

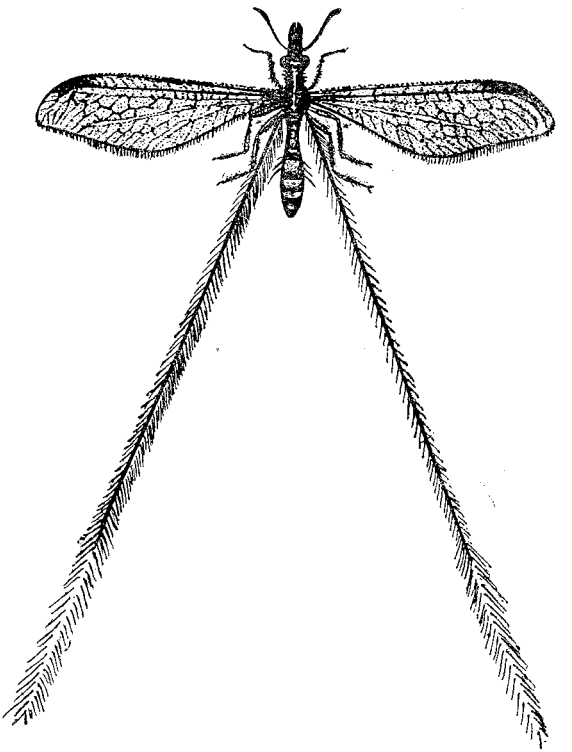
th ehind wings well developed while the front ones are reduced [fig. 10 (4)]. The surface of a typical wing in insects is membranous and in this area there is a net-work of thin thicknened lines called wing veins which strengthen the wing structure and enclose areas or spaces of different sizes, called the wing cells, containing blood and air vessels or tracheoles. In some beetles the wings are fastened to the body along the median line making the insect unable to fly as in some weevils, carabids, etc. The general structure, size, shape, the clothing, and especially the arrangement of the wing veins are so varied that they afford many important criteria in the classification of insects and no attempt is made to describe all these details in this handbook (figs. 10 and 11.). The thorax generally has two pairs of respiratory apertures or



[*Nos.* 6, 8, 11 *Original. Others from different authors.*]

FIG. 10.—DIFFERENT TYPES OF INSECT WINGS.

1. Longicorn beetle.
2. Chalcid Wasp.
3. Coccid—Male.
4. Stylops—Male.
5. Cricket.
6. Lace wing bug.
7. Earwig.
8. Thrips.
9. Ant lion.
10. Plume moth.
11. Leaf hopper.
12. Hover fly.
13. Butterfly.



[*After Imms*]

FIG. 11.—WINGS OF CROCE (NEUROPTERID).

spiracles in adult insects, one on each side of the meso and metathoracic segments.

The Abdomen.—The third and the hindermost of the three body regions is the abdomen (fig. 4). Though it will be almost impossible to clearly make out more than eight or nine segments in the abdomen of most adult insects, embryological evidences show that this region is really composed of eleven separate segments (twelve according to some Entomologists). This reduction in the number of distinct segments to eight or nine is due to the modifications which some of them, especially the terminal segments undergo chiefly as accessory sexual structures. The abdomen is generally the longest of the three body regions, and the body surface is also smoother, pliable and not ordinarily covered with very hard chitin. Except in the case of a few lowly organized insects, where paired segmental appendages are found on the abdomen (as in the Spring tails), the abdominal segments in adult insects do not generally bear any appendages like the legs or wings. In the embroyonic stages of many insects, however, vestiges of abdominal appendages are found and temporary ones also occur, as are the prolegs of the larvae of

moths, sawflies and butterflies. In some primitive insects paired abdominal appendages of their vestiges are noted ; these are found chiefly in spring tails and are different structures known as *callophore, tentaculum, stylus,* etc. In many other insects, the original paired appendages of the three or four terminal segments are modified chiefly to form external or accessory organs of reproduction known as the *genitalia* which surround the genital aperture. The study of these structures till now neglected is now engaging the serious attention of many morphologists and systematists and considerable light is being thrown on their homologies. One of these accessory structures—the egg depositor or *ovipositor* is a conspicuous organ in some female insects often attaining a length much longer than the rest of the insect's body as in some parasitic wasps, some grasshoppers and crickets (fig. 12). This organ is occasionally found

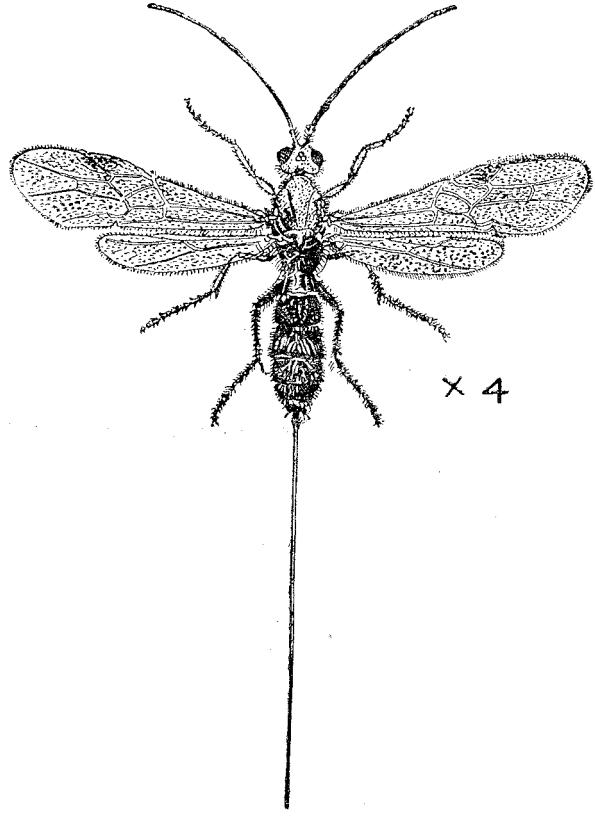


FIG. 12.—WASP SHOWING LONG OVIPOSITOR.

(*Ipobracon kanarensis, R.*)

[*From author's Memoir on Braconidae* 1928.]

in combination with a stinging apparatus also in wasps and bees. At the dorsal extremity of the last segment is found the anal opening and the reproductive aperture is situated ventrally and a little anteriorly, somewhere below the ninth segment. In some forms, the posterior margin of the abdomen may be provided with processes known as *cerci* as in cockroaches and crickets, and in the earwigs a *forceps* like structure is found (figs. 13 and 14). In a line along each lateral side of the abdomen are situated the series

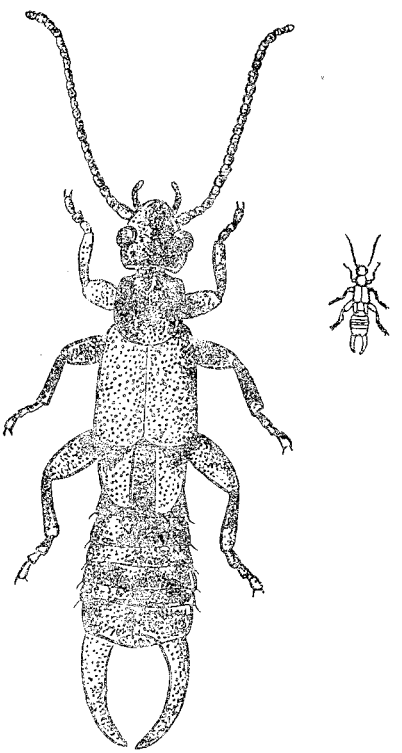


FIG. 13.—EARWIG SHOWING THE ANAL FORCEPS.
(*Nala lividipes*).
[*From S.S.I.*]

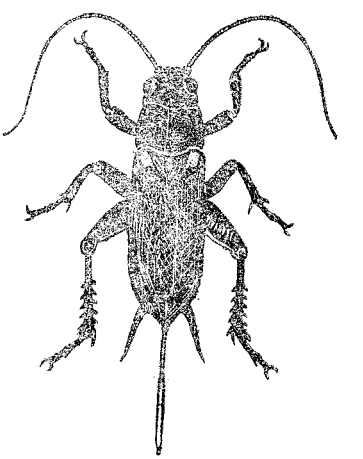


FIG. 14.—CRICKET SHOWING CERCI AND OVIPOSITOR.
(*Liogryllus bimaculatus Deg*).
[*From S.S.I.*]

of external respiratory openings known as stigmata or *spiracles* (fig. 4). These are minute apertures with horny rims situated in the pleural membrane one on each side of the first eight segments; this structure includes in addition to the actual opening, the *vestibule* to which the opening leads and the apparatus for closing and opening the hole. These eight pairs are in addition to the two noted on the two thoracic segments, thus making ten pairs of spiracles normally present in typical insects. These spiracles are more clearly visible in the larval forms than in adult insects.

CHAPTER III.

Internal organs and their functions.

The different systems of the body—Alimentary system—Excretory system—Circulatory system—Respiratory system—Reproductive system—Nervous system.

Similar to most other animals, insects possess all the important internal systems of organs necessary for the proper performance of the various vital functions. The most important of these are the Alimentary or Digestive, the Circulatory, the Respiratory, the Nervous and the Reproductive systems. The fundamental arrangement of the various organs connected with each of these different systems is more or less similar in all insects and as such the internal organization in them does not exhibit such striking or remarkable variations found as in the case of external morphological features. The following brief account which would practically apply to most insects is considered quite sufficient to suit the needs of this handbook, and as such the details in structure and functions are not dealt with. If we open the body of any insect from its dorsal side and expose the body cavity the important internal systems will be found arranged dorso-ventrally in the following order—the dorsal blood vessel or heart which runs along the median line immediately below the dorsal wall; next comes the digestive system including the alimentary canal and its appendages and below that is seen the ventral nervous chain. The organs connected with the reproductive system are found in the posterior region of the abdominal cavity. It must be noted that this arrangement is characteristic of most of the lower animals including all Arthropoda and is quite different from what we find in the higher animals (fig. 15) like fish, reptiles, birds, etc.

The Alimentary system.—This system is mainly made up of the digestive canal which extends from the mouth at the anterior end of the body to the anus situated at the hind end of the abdomen. The length of this canal, the structural modifications of its different regions and the development of accessory structures depend a good deal on the food habits of the various kinds of insects. In its simplest form, the digestive tract is a more or less straight canal running from the oral cavity to the tail-end of the insect as is found in some primitive and generalized groups and in insect larvæ; but in the higher forms which have become gradually specialized in their modes of life and food habits, the parts of this original canal become differentiated into special regions of the system adapted for particular physiological activities. In typical insects like a green grasshopper, the food, which is passed into the mouth by the mouth parts described before, after passing through a dilatation of the oral cavity called the *Pharynx* travels along a more or less straight thin walled

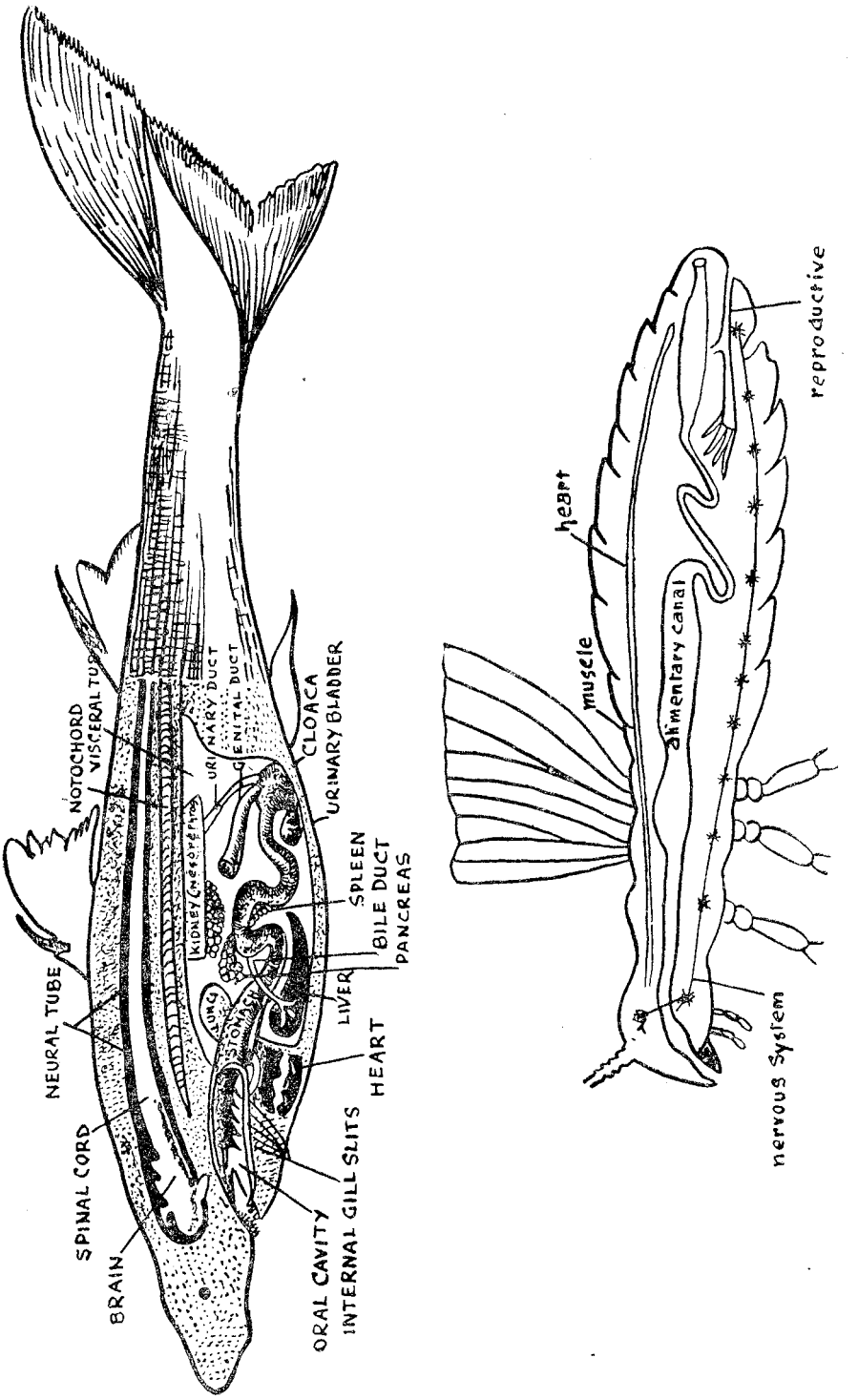


FIG. 15.—SIDE VIEWS OF INSECT AND FISH TO SHOW ARRANGEMENT OF INTERNAL ORGANS.

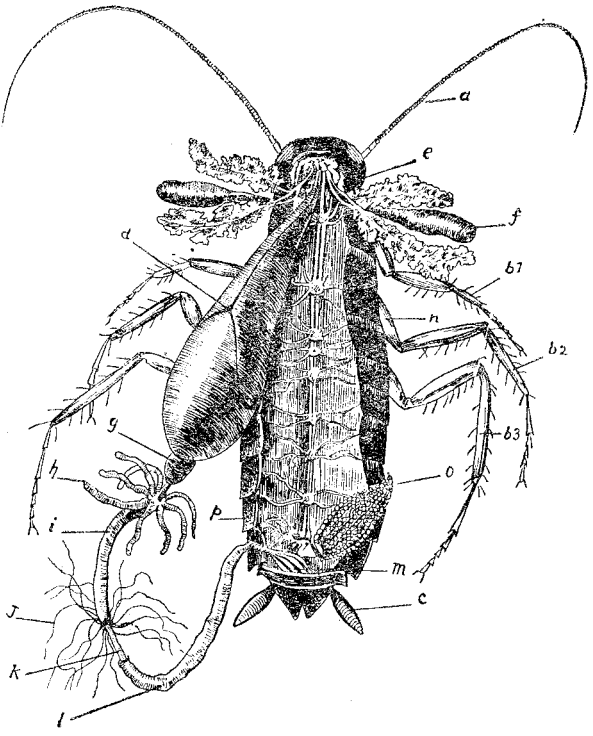


FIG. 16.—COCKROACH—INTERNAL ORGANS.

[*After Rolleston.*]

a Feelers.
b *Legs.*
c Cerci.
d Crop with ganglion on it.
e & *f* Salivary duct and reservoir.
g Gizzard.
h Hepatic coeca.
i Stomach.
j Malpighian tubules.
k & *l* Intestines.
m Rectum.
o Ovary.

along the mid-dorsal region just under the integument and immediately above the alimentary canal; this is called the "*Heart*" or the dorsal vessel and the greater portion of it is confined to the abdominal region. It is closed at the posterior end and has small lateral openings or *ostia* at regular intervals. The blood from the body cavity enters the vessel through these lateral holes and due to the periodical pulsation of the heart the blood is driven forwards towards the anterior end from where it enters the body cavity and gets circulated. The blood in insects is usually colourless though often appearing coloured due to pigments in different forms, and its chief function is nutritive and it does not take part in any respiratory function.

tube, the *œsophagus* and enters a dilated portion called the *Crop* in which part of the food material is retained awaiting digestion. In many insects one or more pairs of salivary glands supplemented in some cases with salivary reservoirs are found lying along each side of the *œsophagus* with their ducts opening into the pharynx. These glands usually secrete the saliva, the alkaline digestive fluid which mixes with the food in the crop ; in the silkworms and many other insect larvæ the silk glands correspond to the salivary glands and produce the silk chiefly used for spinning their pupal cocoons. The crop leads to the *gizzard* or *proventriculus* the walls of which are thick and muscular with the chitinous lining forming sharp edges for macerating and straining the food particles before they pass on further ; this is specially found in insects which take solid food like grass-hoppers, beetles, caterpillars, etc. From the gizzard the canal leads on to the *midgut* or stomach ; at the junction of the gizzard with the latter open a few blind tubes called the *gastric* or *hepatic cœca* which are outgrowths of the anterior region of the stomach. From the stomach, the canal leads on to the hindgut or intestines ; this latter portion is often divided into three different regions—the *ileum* being the narrow region next the midgut, the *colon*, the middle portion and the thick walled *rectum* which terminates at the anus. The typical regions of the alimentary canal are variously differentiated into minor structures according to the food habits of different insects (fig. 16).

The Excretory system.—Unlike as in higher animals insects do not possess any excretory organs corresponding to the kidneys. Immediately behind the stomach at its junction with the hindgut are found attached numerous slender tubes opening into the intestines called *Malpighian* tubules, which perform the function of urinary tubes and which are similar in function to *nephridia* in worms and kidneys in higher animals. These are generally long and slender ending blindly and vary in number from two to more than a hundred. The excretory matter from these tubes is poured into the intestine and passes out only through the anus without any special excretory opening. Though these are the typical excretory organs, the elimination of waste material in insects is also performed to some extent by the general body surface, the trachœa, etc.

The Circulatory system.—In insects the circulatory system mainly consists of a narrow median longtitudinal vessel running

The fat body.—A very conspicuous structure in the body cavity of most insects is the *Fat body,* a many-lobed brightly coloured mass of fatty tissue ; when an insect is opened this organ is found to occupy a good portion of the abdominal cavity covering and enclosing other internal organs ; this structure is found in various shapes and is often made up of branched and lobulated soft tissues. It is found both in the adult and larval insects, but is generally of largest size in the larvae. This body is believed to be a reservoir for conserving food material which is not needed immediately but which may be wanted during certain developmental stages. This is especially the case in insects with a complete metamorphosis. This structure also serves the function of an excretory organ in some insects.

The Respiratory system.—The great majority of insects are land forms and breathe air. In them there are no lungs for respiration. The great majority of them respire by means of a net-work of breathing tubes named *Trachea* which divide, subdivide and ramify as fine walled smaller vessels called *tracheoles* into every minute part of the body. These minute air tubes form a regular net-work and through their thin walls the necessary exchange of air takes place in the living cells of the different parts of the body. These air vessels are elastic tubes with the inner layer having a more or less spiral arrangement and show a characteristic shining silvery colour by means of which these could be easily recognized and distinguished from other internal tissues of the body. This system of trachea communicates with the outside through lateral openings in the body called *spiracles* or stigmata which are fitted with opening and closing apparatus of different kinds ; there are ten pairs of spiracles in typical insects, two in the thorax and eight in the abdomen. Most of the aquatic insects come up to the surface of the water to breathe though a few, especially larval forms, possess lamellate structures like gills. Among insects two types are found, the tracheal gills and the blood gills ; the former are more commonly found than the latter which exist only in some coleopterous and chironomid larvae ; tracheal gills occur in neuroptera, and some caterpillars, etc. These are of course different from those of a fish. The different types of respiration found among insects vary with the arrangement of the spiracles in the larvae or adults. These different types are known as *Holopneustic* (arrangement found in most insects—ten pairs of spiracles open). *Hemipneustic* (some open and others closed—in most larvae) and *Apneustic* (with all spiracles closed or no spiracles as found in some larvae).

The Reproductive system (*fig.* 17).—The sexes are always separate in all insects and the chief organs of reproduction are situated in the abdominal cavity. The essential generative organs in the male are the paired testes and their ducts and in the female the paired ovaries and their oviducts. In many insects these primary organs

are supplemented by accessory structures of different kinds more or less corresponding to each other in both sexes (fig. 17). In addition to these essential internal organs there are external structures which form the external genitalia. Those in the male consist

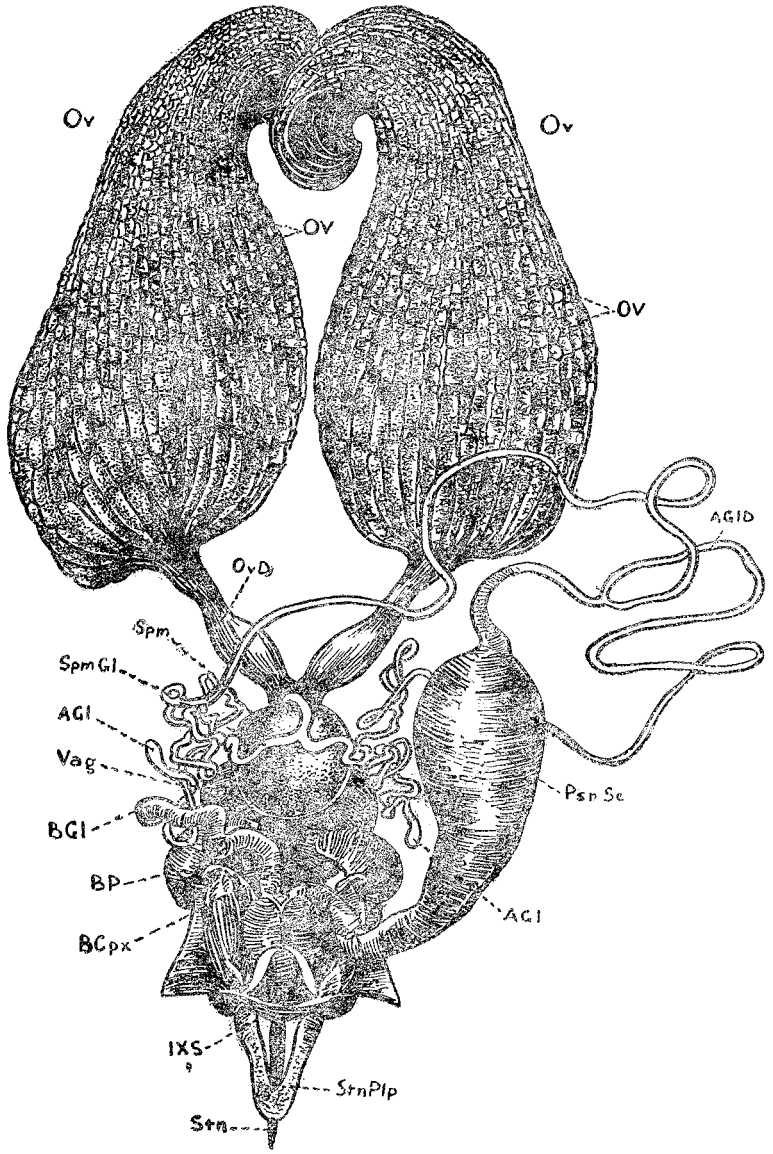


FIG. 17.—REPRODUCTIVE ORGANS AND STING OF QUEEN BEE.
Ov.—Ovary. Spm.—Spermatheca. OvD.—Oviduct. Agl.—Acc. gland. Stn.—Sting.
[*After Snodgrass; only important parts referred to.*]

of claspers and penia while in the female we find the egg depositor called the *ovipositor* already referred to before in describing the abdominal region. The external genital openings are generally situated near the posterior end of the abdomen towards the ventral side usually ventral to the ninth abdominal segment.

The Nervous system (*fig.* 16).—The main or central nervous apparatus in insects is composed of (1) a median ventral nerve chain made up of a double row of nerve ganglia closely connected together, (2) the two masses of nerve ganglia, viz., the supraœsophagial ganglia or the brain placed above the alimentary canal and the sub-œsophagial ganglia situated just below the alimentary canal both being connected by nerves which enclose the digestive canal in the loop. In primitive insects the ventral nerve chain shows a pair of closely placed ganglia for each body segment, but in the highly organized and specialized forms many of these paired ganglia often unite together into one compound ganglion. The study of insect development has shown that the brai and the sub-œsophagial ganglia are formed as a result of the fusion of several original ganglia of the head region in the same way as the segments of the head. The brain and the sub-œsophagial centres supply nerves to and control the activities of the sensory organs, antennæ, eyes, etc., and the mouth parts ; the nerve centres in the thoracic and abdominal ganglia govern the functions of their respective segments though in many insects the ganglia of a number of body segments are found fused together. Besides the central nervous apparatus noted above there is, also found a sympathetic or stomodæal system which is believed to exercise some control over the heart, part of the alimentary system including salivary glands, the spiracles and generative organs.

The Sense organs.—With the nervous system are closely associated what are called the sensory organs, organs which receive and transfer impressions received from the effect of the changes in the environment. These organs chiefly include those of sight, touch, hearing, smell and taste. We have already noted the eyes ocelli and the antennæ which are concerned chiefly with vision and touch. The special structures or sensillæ connected with the tactile function or sense of touch are found all over the body surface though especially in the feelers and the mouth parts ; the senses of smell and taste are chiefly possessed by the feelers and the different parts of the mouth parts such as the palpi, hypopharynx, etc. In insects there are no ears as in higher animals but some of them appear to possess organs which show powers of hearing and response to sounds. These auditory or *chordotonal* organs are small specialized areas of the body surface or plates (*tympana*) found in many insects, but they are specially noticeable in grass-hoppers and crickets ; in the former they are situated on each side of the first abdominal segment and in the latter on the tibia of each fore-limb (fig. 18).

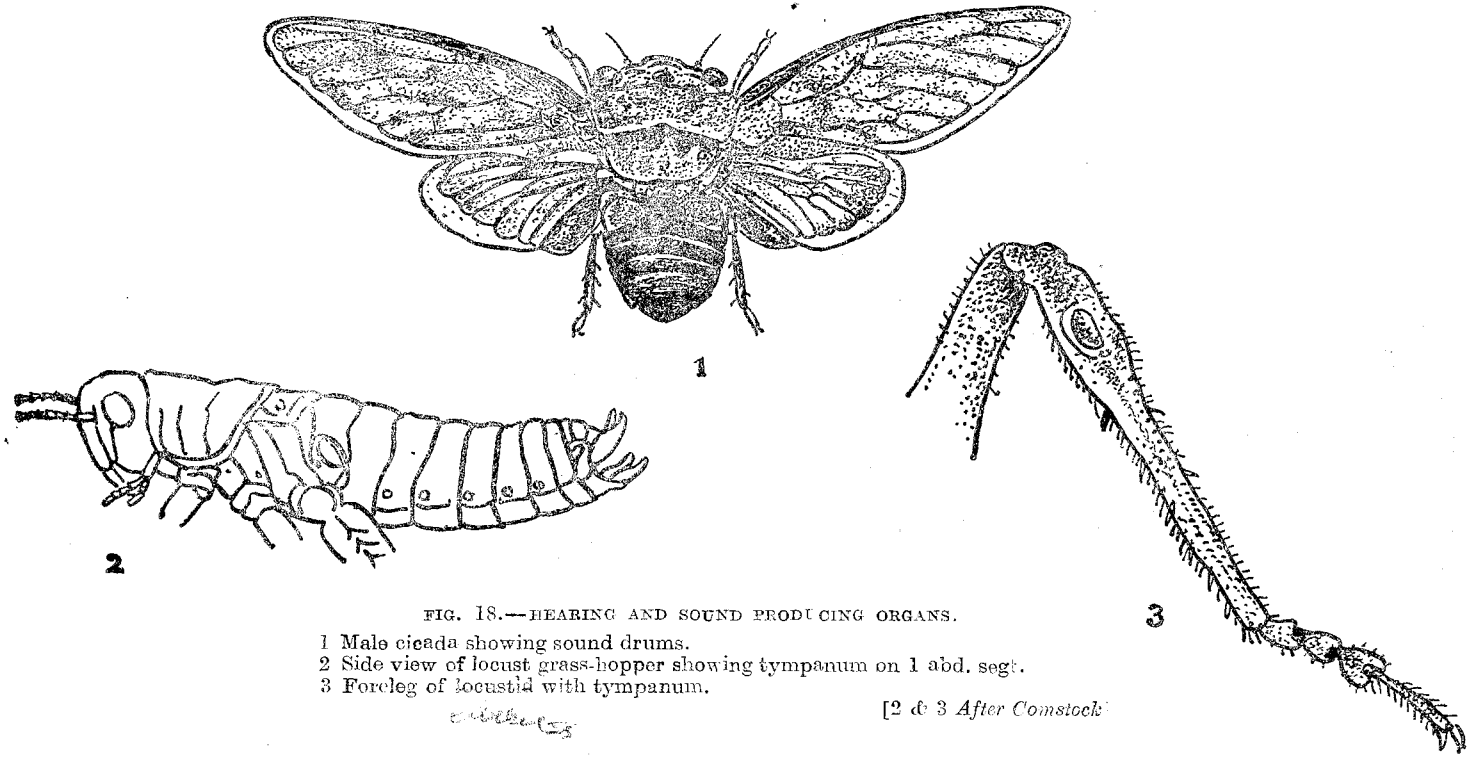


FIG. 18.—HEARING AND SOUND PRODUCING ORGANS.

1 Male cicada showing sound drums.
2 Side view of locust grass-hopper showing tympanum on 1 abd. segt.
3 Forcleg of locustid with tympanum.

[2 & 3 *After Comstock*

Many insects are well-known sound producers either singly or in chorus and some of them appear to understand and respond to such sounds. Well-known examples are the Cicadas, Crickets, Grasshoppers, etc. Sound is also produced by various beetles, moths, wasps, and even some larval forms. The sound is produced in various ways such as by the striking or rubbing of a part of the body to an external object or to another part of the body or by vibrations of different kinds made by different parts of the body such as legs, wings, body segments, etc. The special structures concerned in the production of such sound are usually known as stridulating or rasping organs and are found chiefly on the wings and hind legs. The sound organ in the Cicada is very characteristic and is found only in the males ; the organs consist of two plates or opercula on the ventral side of the body at the junction of the thorax and abdomen ; these cover the internal delicate parts or drums which vibrate and produce the shrill noise (fig. 18).

Some insects have also the capacity to produce light ; well-known examples of luminous forms are the glow-worm beetles and fire-flies. The Indian glow-worm beetle (*Lamprophorus tenebrosus*, W) is a very good example ; both the male which is the winged 'firefly' and the female which is the wingless 'glow-worm' are capable of emitting light.

The muscular system which is concerned with body movements and locomotion is closely connected with the nervous system and it is unnecessary to enter into their details here. It is sufficient for our purpose to state that insects are remarkably well supplied with muscles for their numerous movements and the fact that these creatures are wonderfully adapted for the multifarious activities is in a great way due to the remarkable efficiency and powers of endurance of their muscles.

CHAPTER IV.

Insect Reproduction, Development and Multiplication.

The sexes.—As stated before, the sexes are always separate in insects ; but it is often difficult to distinguish between the two sexes from their external appearances alone. In some forms, however, there are certain external or secondary sexual features such as colour, size, differentiation in external structures, etc by means of which they could be distinguished. Generally the male is smaller than the female ; in some cases like flies, bees, etc., the male insect has the

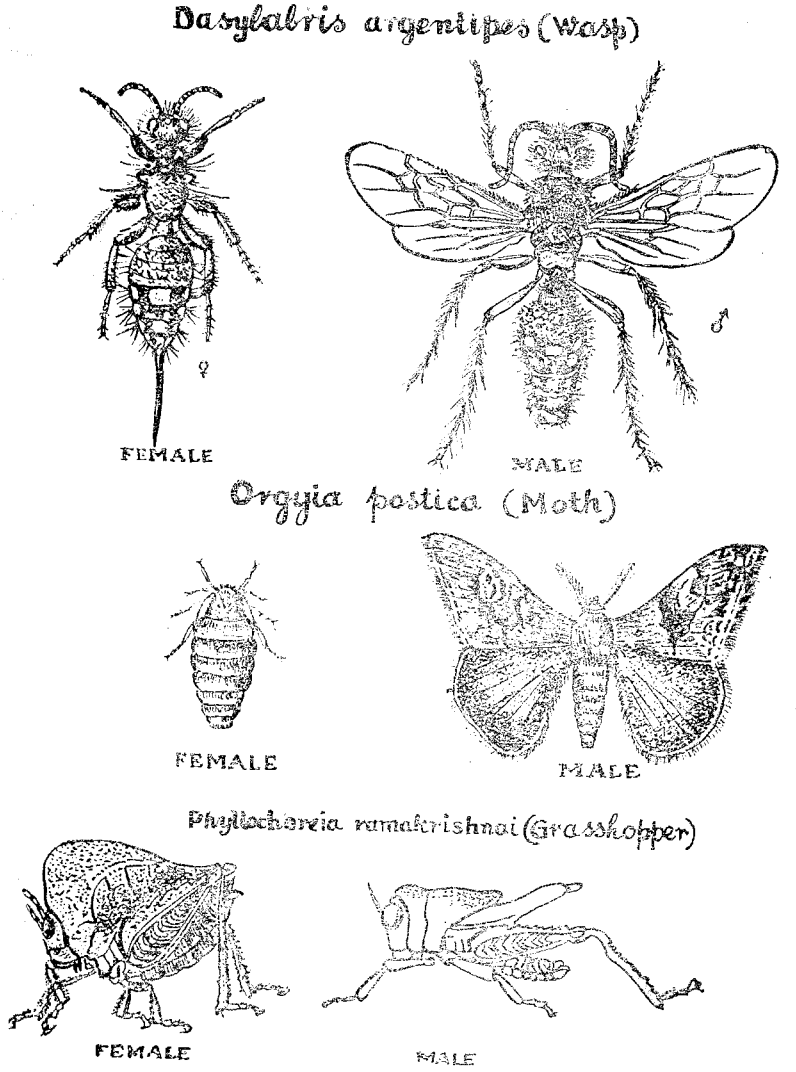


FIG. 19.—SEXUAL DIMORPHISM IN INSECTS (South Indian examples).

eyes much larger than the female. In some species, especially, in some of the parasite wasps, the female insect has an elongated ovipositor which is very conspicuous and easily helps one in determining the sex. In some forms, the males alone possess wings while the females are apterous as in velvet ants, scale insects, some bagworm and tussock moths, etc ; in some forms as in mosquitoes and some moths, the males have very bushy and hairy antennæ (fig. 19). In some other forms, the colour and some of the external features of the two sexes are so strikingly different that they are often mistaken for two different species. This is strikingly seen in the scale insects, strepsiptera, hymenoptera, moths and grasshoppers. '*Hermaphroditism*' or the existence of both the male and female generative organs in the same individual is almost entirely absent among insects though a few cases have been recently noted by workers, one being the Coccid *Icerya purchasi*, where the condition is said to be even functional. A phenomenon called *Gynandromorphism* showing the external features of both male and female in the same individual is sometimes found among bees and some lepidoptera.

Mating and Oviposition.—As in higher animals, reproduction takes place as a result of the union of the two sexes in the great majority of insects. In a few forms, however, it is found that the female insect is able to reproduce normally without mating with the male ; this phenomenon is known as *Parthenogenesis.* This is chiefly found in some bees, plant lice and scale insects among which the males are often very rare and sometimes never found. With very few exceptions all insects as a general rule develop from eggs laid by the mother insect. Those forms which do not lay eggs but give birth to active young one, as in some plant lice, are known as *Ovo-viviparous* forms. *Polyembryony* is another phenomenon where more than one offspring is produced asexually from a single egg ; this is noted among some chalcid wasps.

Similarly there is another curious phenomenon among some insects where some immature stages are capable of producing further larvae ; this is known as *Paedogenesis.* The number of eggs laid, their size and form, and the modes and situations in which they are deposited vary remarkably among different insects. The number

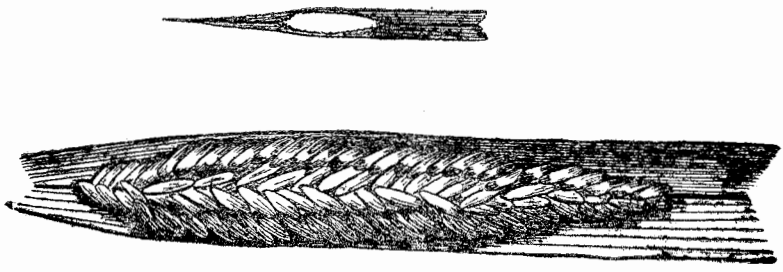


FIG. 20.—EGG MASS OF TABANID FLY.

[*From S.S.I.*]

varies from as few as two or three to as many as thousands ; while the honey bee queen and the termite queen are known to lay two to three thousand eggs a day for weeks together, the average number among insects may be put down at about a hundred eggs. Some lay their eggs singly while others deposit in patches or clusters (fig. 20). In size, eggs of insects are generally very small and often microscopic though none exceeds a sixth of an inch in diameter. In shape and structural peculiarities they vary remarkably. Some are oval, some cigar-shaped, others cylindrical, some others stalked (fig. 22), others boat-shaped and so on ; the general surface may be smooth, ribbed, grooved or beautifully sculptured and provided in some with a cap or lid. The situations in which the eggs are laid and the manner of ovi-position vary and depend a good deal on the food habits of the insect concerned. Usually the eggs are laid on or near the object which is to form the food of the hatching offspring and since from the moment of hatching the young one of most insects has to lead an independent life and shift for itself, the suitable situations for egg-laying are very carefully and instinctively selected by the parent insects—as for example the eggs of a leaf-eating caterpillar or beetle are laid on those particular leaves and those of mosquitoes and other aquatic insects on water, those of parasitic forms on their host plant or animal, and so on. Examples of insects showing parental attention over eggs and young ones are met with among some insects such as the plant bug *Cantao*, earwigs, etc. (fig. 21). The period of incubation of eggs in insects varies from a few hours as in the case of the house-fly to several months as in the case of some grasshoppers.

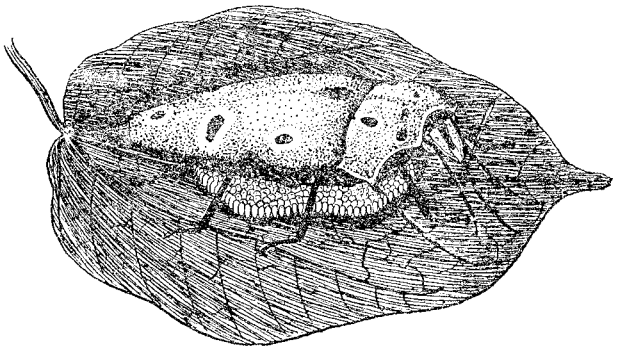


FIG. 21.—MATERNAL CARE OF EGGS IN BUG (*Cantao occellatus*)

[*From S.S.I.*]

Development and metamorphosis.—In studying the development of an insect from its egg to the adult condition it will be found that there are two distinct aspects in the gradual growth and change of form taking place during this intervening period ; one is the series of changes which take place inside the egg up to the time it hatches into an active offspring and the second one is the gradual development and growth of this active embryo from the time it hatches out

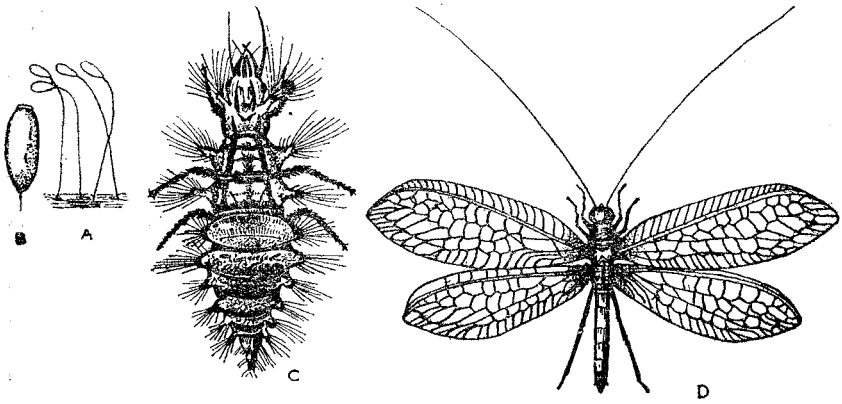


FIG. 22.—LACE WING FLY (*Chrysopa celestus B.K.*) STAGES.
(Eggs, larva and adult.)

[*After Zehutner*]

of the egg to the adult condition when it is able to reproduce. The former is generally called the embryonic development inside the egg and the latter as the post-embryonic. While the embryology of insects inside the egg-shell is practically similar in most cases and a phenomenon common in other animals, the post-embryonic development among insects is a very characteristic and remarkable feature among them. The progress of growth among many insects hatching from the egg to the adult stage is often followed by striking and extraordinary transformations in form—a feature not common among other animals. This series of changes in the post-embryonic development exhibiting striking differences in the different stages of growth is known by the term *Metamorphosis*. Among insects there are some forms which have no metamorphosis, others which have a partial metamorphosis and many others with a complete and complex metamorphosis. The first group includes those insects in which the young ones do not differ from the parents in form, structure or habits ; the growth in such cases is just as in higher animals. The insects coming under this category are called *Ametabola* and include the few primitive insects like silver fish, spring tails, etc. Under the second group we find such insects which exhibit only a gradual change in general structure (*Heterometabola*) ; the only striking change in structure as the young one approaches the adult condition is the growth of the wings. Grasshoppers, cockroaches and bugs of different kinds are the chief examples (fig. 23). The third group includes the great bulk of known insects and is known as *Holometabola*. The metamorphosis in these insects displays striking differences not only in structure but also in the general habits between the larval stages and the adult. In every insect, whether it exhibits a metamorphosis or not, three distinct stages could be made out in its life history, viz., (1) the *egg* stage, (2) the active feeding and growing stage known as the *Larva*, and (3) the *Adult* or reproducing stage ; but among those insects which have a complete metamorphosis a distinct intervening stage between the larva and the

adult called *pupa* stage is always found, thus making four distinct stages in their life history. All beetles, flies, butterflies, moths, bees, wasps and ants come under this group—the *Holometabola* (figs. 24, 25 and 26). The accompanying tabular diagram (fig. 29) will give a general idea of the phenomenon of metamorphosis in its different aspects among insects. In a few insects a phenomenon known as "*Hypermetamorphosis*" is found to occur; here the larva passes through at least two different stages before pupation, viz., the *Thysaniform* and *Eruciform* larvae. This is the case in some blister beetles, small wasps and strepsiptera (fig. 27).

Growth.—From the time of their hatching from the eggs up to their assuming the adult stage all insects exhibit the phenomenon of skin shedding, the process being known as *moulting or ecdysis.* The exoskeletal covering of the body in insects being made of hard chitin which is practically non-living matter, the individual is not capable of increasing in size with the growth of the body underneath it; therefore, during the growth of an insect the outer chitinous covering is periodically shed or cast off and a fresh cuticle formed every time. This periodical shedding of the cuticle is a characteristic feature among insects during their developmental stages and this process is regarded to help excretion also through the integument. The number of such moults passed by the young one is normally five or six, but varies with different kinds of insects and is, in some cases, dependent on climatic and other factors; it varies from two or three to seven or eight and the intermediate stages

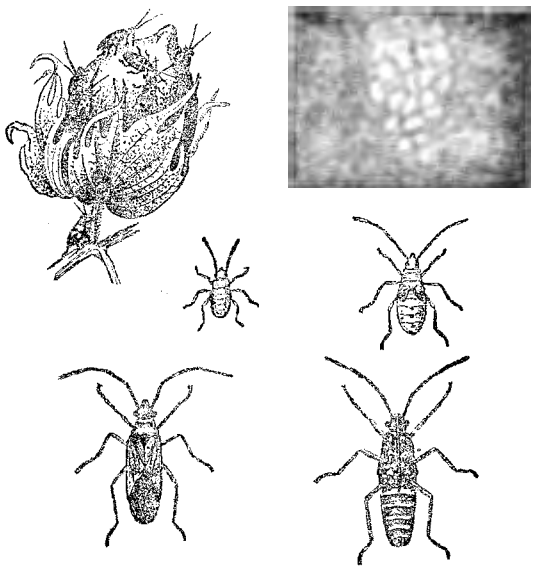


FIG. 23.—RED COTTON BUG STAGES (*Dysdercus*), (Egg mass, nymphs and adult.)

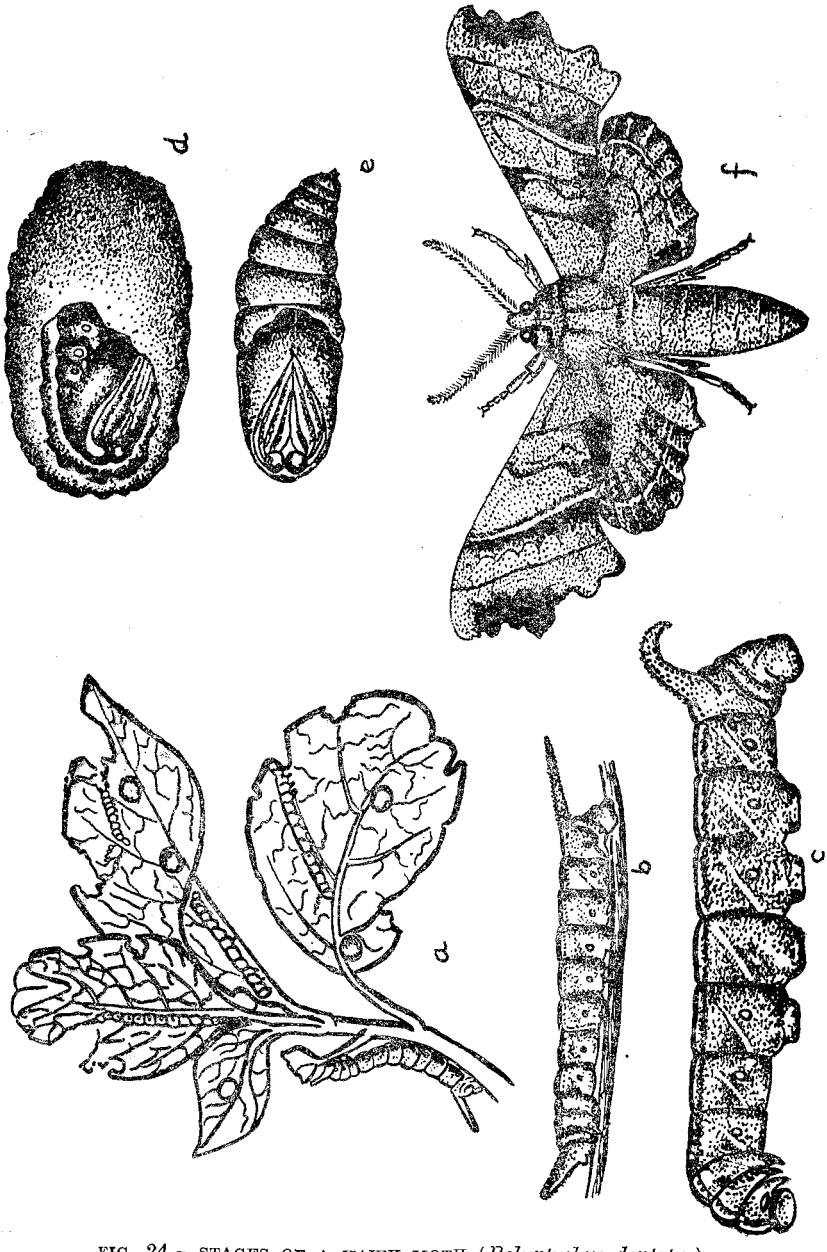


FIG. 24.—STAGES OF A HAWK MOTH (*Polyptychus dentatus*).
a Eggs and young larva. *b* & *c* Growing caterpillars.
d & *e* Pupa. *f* Moth.

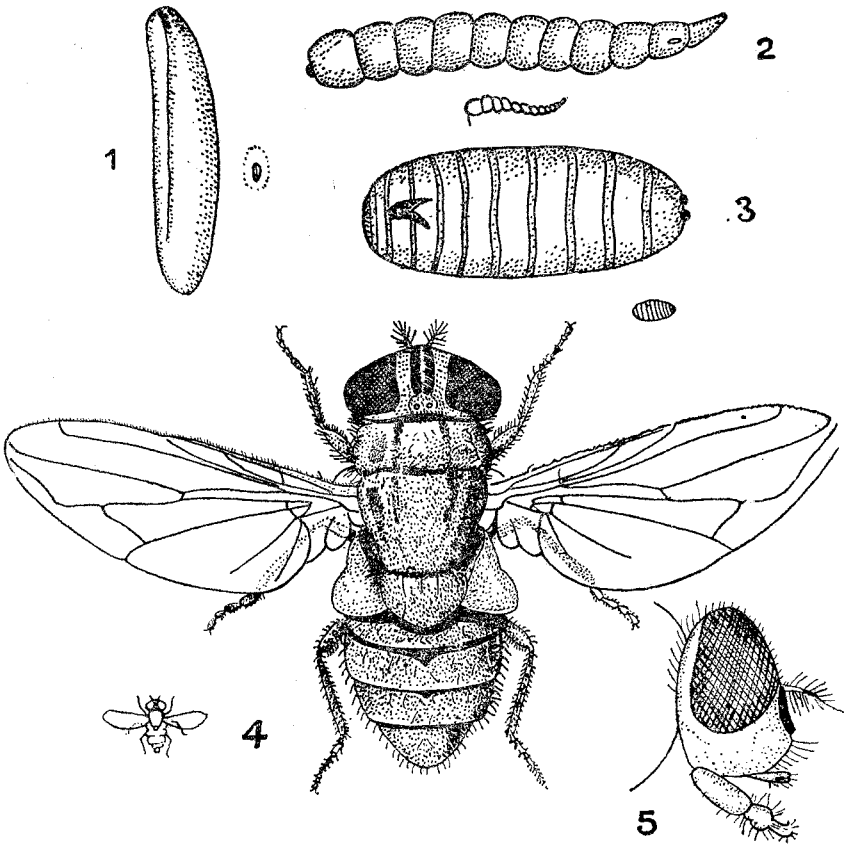


FIG. 25.—FLY (*Musca crassirostris, S*) STAGES.
1. Egg. 2. Maggot, 3. Pupa. 4. Adult. 5. Eye.
[*From S.S.I.*]

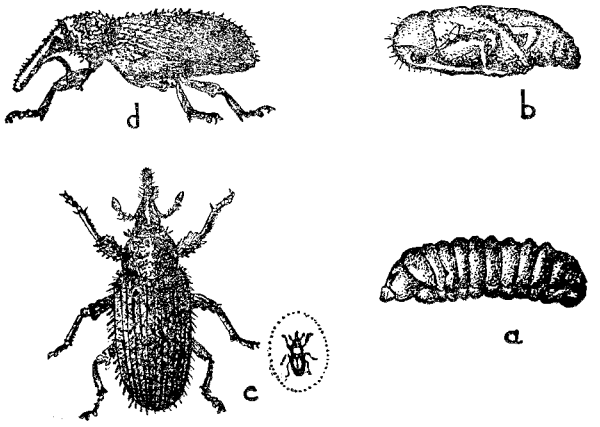


FIG 26.—JAKWEEVIL (*Ochyromera artocarpi M.*) STAGES.
a Grub. *b*. Pupa. *c* & *d* Weevil dorsal and side views

between such moults are generally known as *instars*, that stage immediately after hatching from the egg being reckoned as the first instar. No moults are passed nor does any increase in size take place once the insect has reached its adult condition; the popular notion that little flies and beetles grow into big flies and big beetles is a mistaken one. While the first stage in the life history of an insect is known as the *egg*, the second stage is popularly known as the *larva* or nymph according as the metamorphosis is complex or simple; the larvæ of different groups of insects often take special forms and (Fig. 28) are known by special terms—that of the beetle or a wasp as a *grub*, that of a butterfly or moth as a *caterpillar*, that of a fly a *maggot* and those of such insects like grasshoppers, plant bugs, etc., are known as *hoppers* and *nymphs*. As stated above, the early stages of those groups of insects which pass through a complete metamorphosis show remarkable differences in general structure and habits when compared with their parents. For instance, the caterpillar of a moth or a butterfly has an entirely different appearance and build, and feeds in a way quite different from its parent; while the caterpillar with its

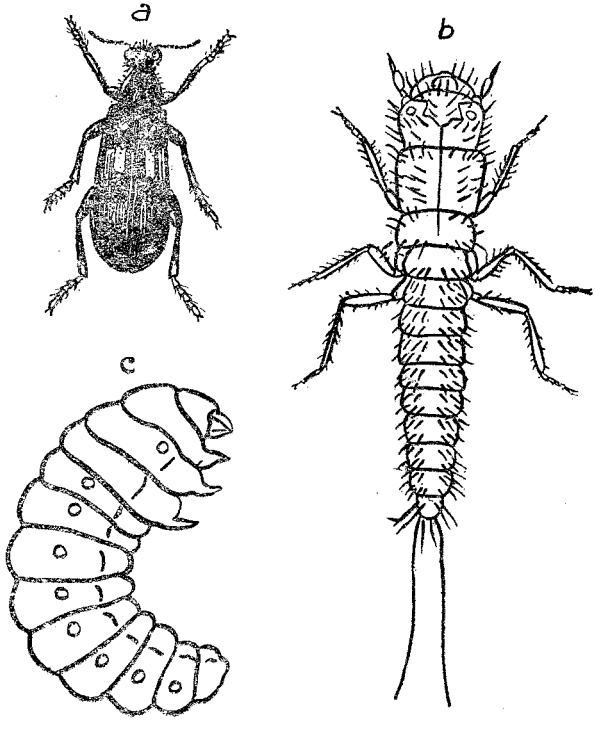


FIG. 27.—ZONABRIS PUSTULATA (stages in hypermetamorphosis).
a Beetle. *b* Earlier larva. (Campodiform) *c* Full grown larva. (Eruciform)
[*After Roepke*]

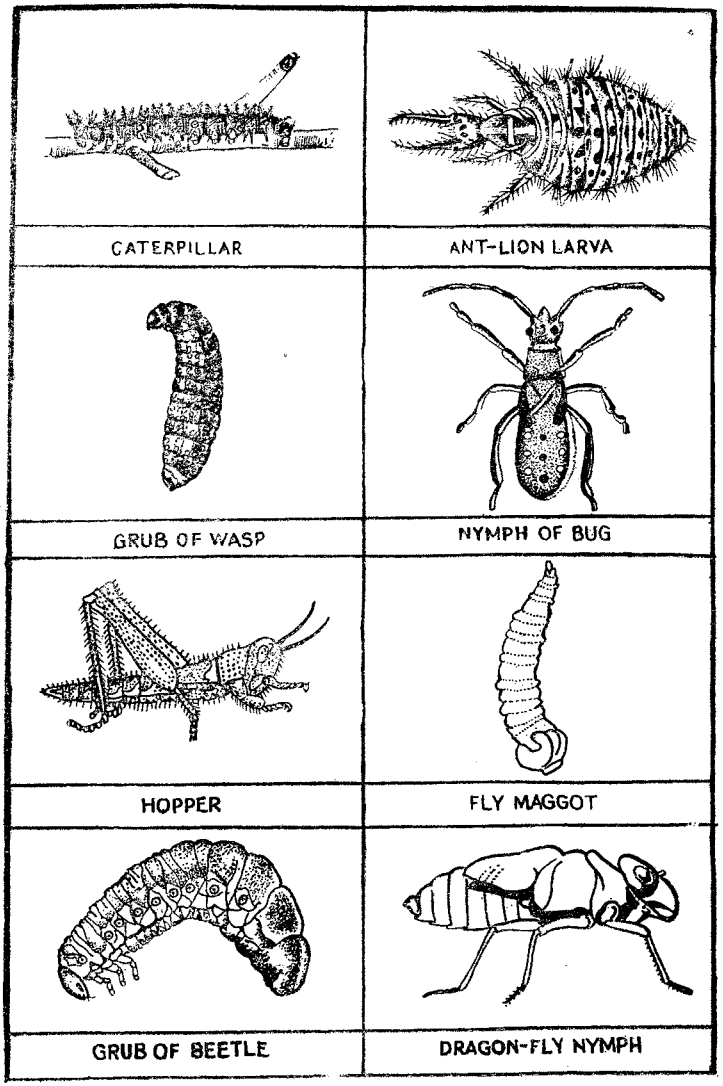


FIG. 28.—LARVAL FORMS OF SOME INSECTS.

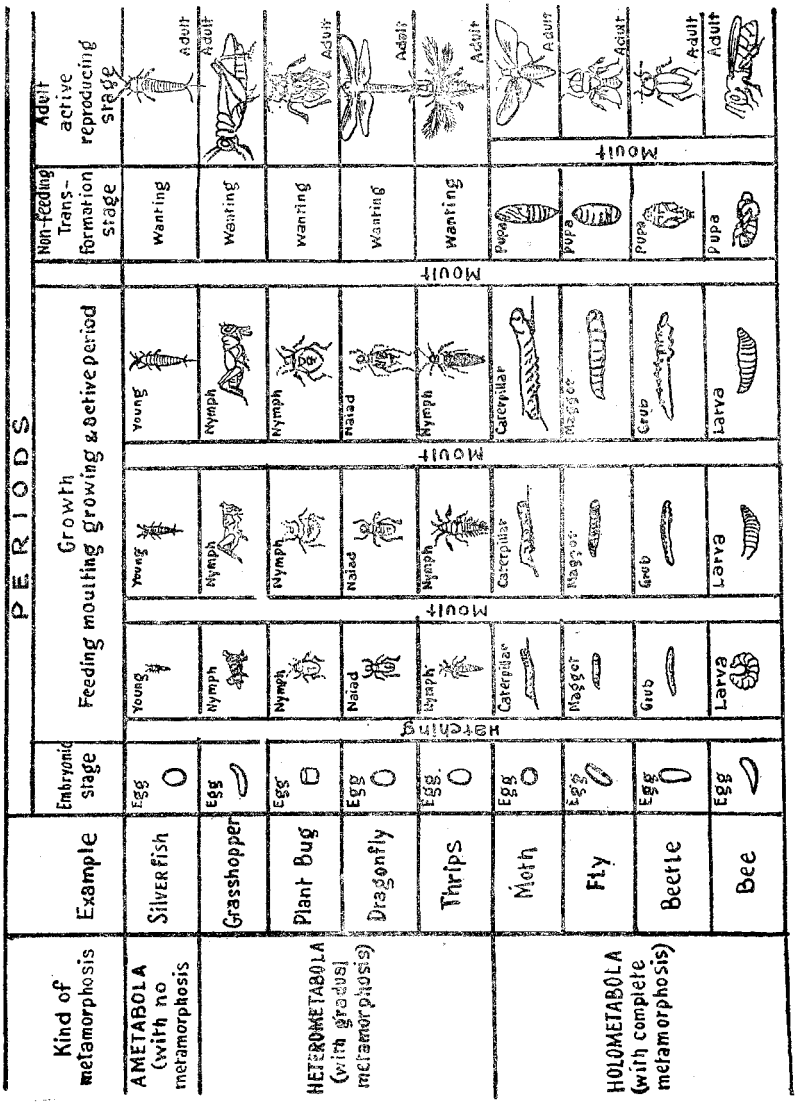


FIG. 29.—METAMORPHOSIS OF INSECTS (different types).
[*From Metcalf.*]

elongated and cylindrical body crawls on the surface, and has biting mouth parts capable of feeding on solid vegetable tissue, the mother insect is a winged form flying in the air and with the mouth parts adapted only for feeding on liquid nutriment. This is more or less the case in the groups of beetles, wasps and flies also. The length of the larval life varies with different insects—from a day or two as in the case of flies and mosquitoes to several months and years as in some grasshoppers, beetles, moths and the 17-year Cicada of America—*Tibicina septendecim, L.* When the larva has fed fully and attained its full growth after passing through the usual moults it stops feeding and changes into the next stage—the quiescent, non-feeding *pupa* and remains in this condition until it emerges as the full fledged adult. During this pupal stage the insect is in a practically helpless condition, and as such in many forms it is enclosed in a cover or *cocoon* prepared by the mature larva before changing into the pupal condition. It is during this stage that all the future organs of the adult develop inside the pupal case. The pupation period also varies with different insects ; it ranges from a day or two as in flies and mosquitoes to several months as in some moths. In insects with partial or no metamorphosis the larva gradually changes into the adult stage after the usual moults without a pupa stage (fig. 29).

Length of life and rate of multiplication.—Compared with higher animals, most insects are comparatively short lived in the adult stage ; but to make up for this they possess remarkable powers for rapid multiplication. As stated above, insects give rise to numerous offspring which, in their turn, produce further generations in a very short period of time compared to higher animals and thus increase in numbers rapidly. These two advantages of greater fecundity and shorter life cycle play a very important part in maintaining the remarkable numerical strength of many insects. According to Hodge " a pair of flies beginning operations in April, might be progenitors, if all were to live, of 191,010,000,000,000,000,000 flies by August, and allowing $\frac{1}{8}$ cubic inch to a fly, this number would cover the earth 47 feet deep !" But, fortunately nature keeps up an even balance in the world without allowing any one creature to multiply extraordinarily and become a nuisance—the important factors which play their part in such work being climatic conditions, natural enemies and the food problem as explained in Chapter VII.

CHAPTER V.

General Features in the activities of Insects.

Habitat and food—Protective and other adaptations—Insect behaviour and inter-relations—Their relations to other organisms—Insect distribution and dispersal—Size and numerical strength.

It is well known that, of all the various activities exhibited by animals, the most important ones are those connected with their three vital needs, viz., the supply of food, protection from enemies and weather conditions, and the propagation of the species. The struggle for existence, we see going on every day around us in nature is, in fact, the manifestation of the activities of all living beings to satisfactorily provide these primary needs. There is hardly any biological study more absorbing and fascinating than that of the various structural peculiarities and striking adaptations possessed by insects, their diverse activities and behaviour, their reactions and responses to their environments and numerous such factors which play their respective roles as "shifts for a living" in the words of Professor Thomson. In this chapter an attempt is made only to very briefly touch upon some of the more important and outstanding general features in the life activities of insects; for, it is impossible to do anything like justice to such a very varied aspect of entomology even in a whole book devoted for this purpose.

Habitat and food.—The great majority of insects are land forms and comparatively few are found leading an aquatic life; of the latter, only a very few species are actually known to live in the sea, (the well known one is a bug *Halobates*), the rest being found only in fresh water. Among the fresh water forms the common ones include the water beetles and aquatic bugs which live in water all their life; in the case of many other aquatic insects it is only the immature stages which lead an aquatic life. Familiar examples of such insects are the mosquitoes, dragon flies, may flies, caddice flies and midges. All such forms which lead an aquatic life either during the larval period or throughout life have the necessary structural adaptations to perform their vital functions suited to their special habitat, especially for locomotion and respiration (figs. 30 and 31). A study of the general structure and habits of these insects goes to show that all the aquatic forms have descended from ancestors which were originally land living species. Among insects living on land the haunts are diverse and very numerous. Some are surface living insects, some underground forms, and many others live on vegetation of different kinds such as grass, shrubs, trees, etc.; some live in buildings such as farm houses, stores, mills and human dwellings, some are found in forests and in the deserts and yet others are found not only on the bodies of other animals but on other insects as well. In fact, in most cases, to be found in the

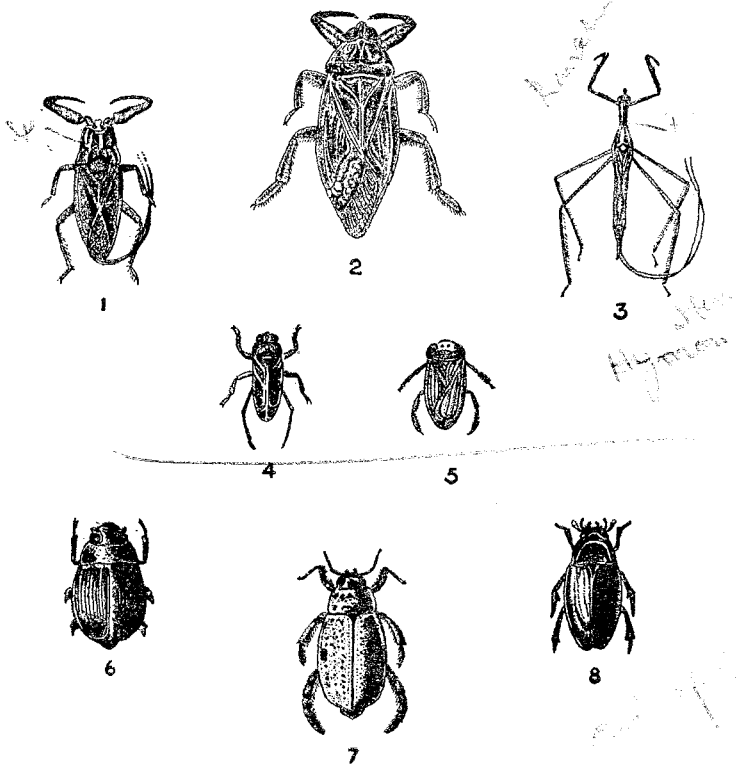


FIG. 30.—SOME WATER INSECTS.
1-5 Water bugs. 6-8 Water beetles.

1. **Laccotrephes robustus, S. (Nep)**
2. **Belostoma indicum, L. (Bel)**
3. **Ranatra elongata, F. (Nep)**
4. **Enithares indica, F. (Not)**
5. **Micronecta striata, F. (Cor)**
6. **Dineutes indicus, A. (Gyr)**
7. **Eretes sticticus, L. (Dyt)**
8. **Hydrophilus olivaceous, F. (Hyd)**

midst of or in the vicinity of its food material. We have even example of insects noted breeding in petroleum wells and salt mines. From the point of view of the nature of the food of insects also we can group them into two or three main subdivisions such as herbivorous or plant feeders, carnivorous or animal feeders and scavengers feeding on dead, dry or rotting animal or vegetable matter ; and each of these subdivisions includes different smaller groups according to the special nature of their food material, whether plant or animal. Even among insects, as in higher animals, there are some which confine themselves for their food to particular and specific kinds of plant or animal (*Monophagous*) and others which are feeders on different materials and

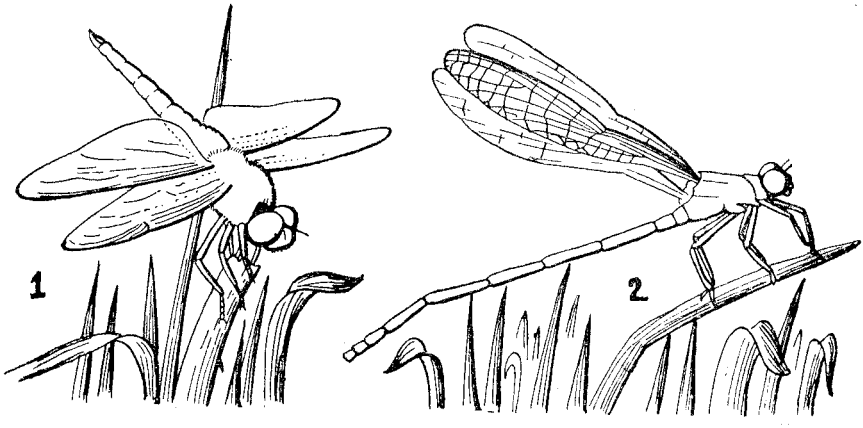


FIG. 31.—DRAGON FLIES.
1. Aeschnine. 2. Agrionine.

[*After Lefroy*]

are not exclusively monophagous (*Polyphagous*). Those that are plant feeders (*Phytophagous*) form a very great number, including as they do many of our insect pests which affect our crops, stores, etc.; animal feeders include the parasitic and predatory forms some of which are injurious and some beneficial to man.

Insect adaptations.—Remarkable are the various structural peculiarities and adaptations which many insects are endowed with to help them in securing their food and shelter and protecting themselves, not only from unfavourable weather and seasonal conditions, but also to guard against their various enemies. As adaptations for securing food we have already made reference to the modifications in the mouth parts of different insects; in some forms as in the common *mantis*, the dung rollers and aquatic forms, the legs are specially modified for help in various functions. Among many insects the construction of a lodging for protecting themselves against unfavourable vicissitudes of life and to provide lodging for their offspring is an instinct. Many forms hide themselves during the day under the soil, under stones, under bark, etc., and are active at night; others remain in nests and houses constructed by their own ingenuity in a variety of ways. Conspicuous examples of such forms are the ants, wasps and bees which build their underground or arboreal nests. The instinct to construct a protective lodging for the young ones is particularly noticeable among such insects which pass through a complete metamorphosis where the helpless pupa has to be protected from extremes of weather and enemies; the mature larvæ, in such cases, construct shelters called *cocoons* around their own bodies before they assume the pupal stage. This cocoon may be made of earth, silk, frass, fibre, hair or other materials according to the natural habits of such insect; examples of insects which construct shelters for themselves even in their

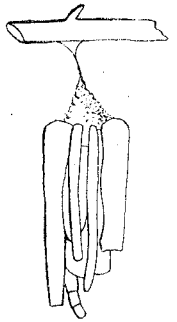


FIG. 32.—BAG WORM AND MOTH.
(*Clania crameri.* W.)
[*From S.S.I.*]

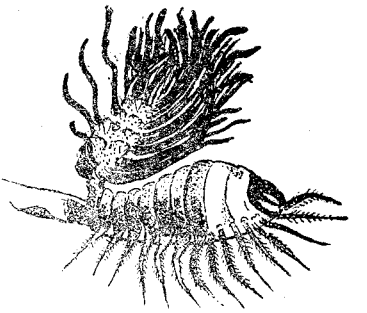


FIG. 33.—A TORTOISE BEETLE LARVA CARRYING ITS EXCREMENT OVER ITS BACK.
[*From S.S.I.*]

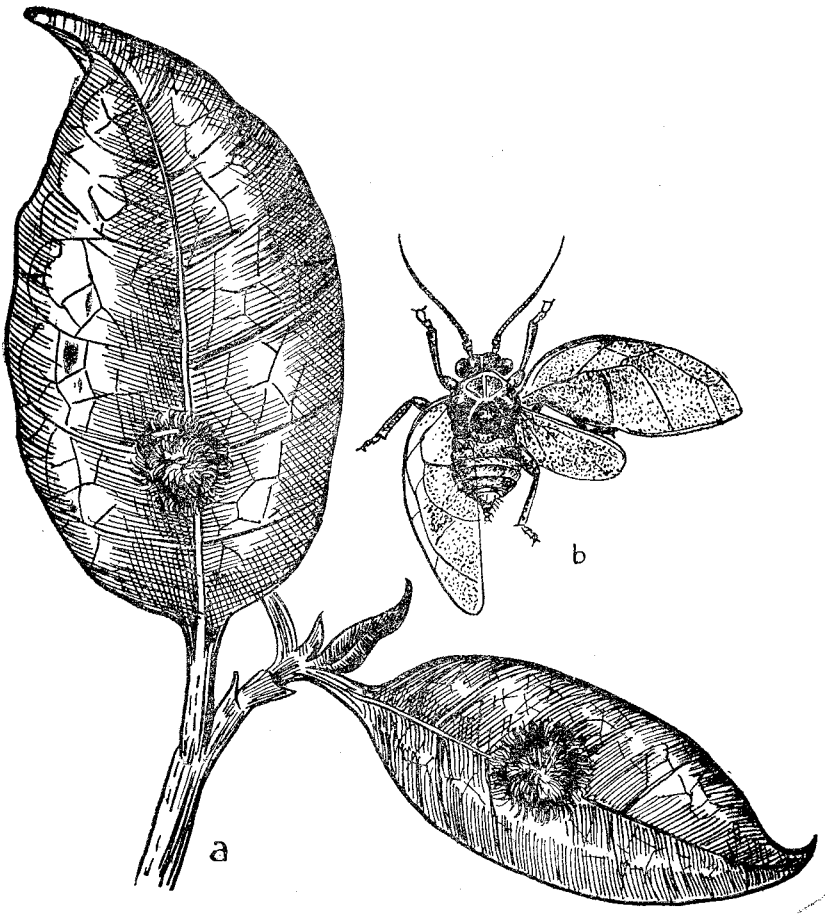


FIG. 34.—PSYLLID GALLS ON FIG LEAVES (*Dinopsylla grandis*, C.)
a **Twig** with two galls. *b* The adult

active feeding stages are the bag and case worms which construct tubular cases or bags of leaves, twigs or silk, the larvæ of some tortoise beetles and lace wing flies (*Chrysopa*) which move about covering their bodies with their own excreta or the carcases of their victims and gall insects of sorts like thrips, psyllids, flies, etc., which produce galls on plants (figs. 32–34). In many insects natural protection is afforded by the external body covering and the armature of the different parts of the body. The hard cuticle of various beetles and bugs, the spines and tubercles of many grasshoppers, caterpillars, bugs and beetles, the stinging organs of the many bees, wasps and ants, the piercing proboscis of bugs, mosquitoes and biting lice, and the poisonous spines and irritating hairs of many caterpillars are examples of some of the numerous adaptations met with among insects for defensive and offensive purposes (fig. 35). As a means of protection and perhaps for defensive and offensive purposes as well, some insects possess the habit of rolling themselves into a ball (fig. 36) or throwing out,

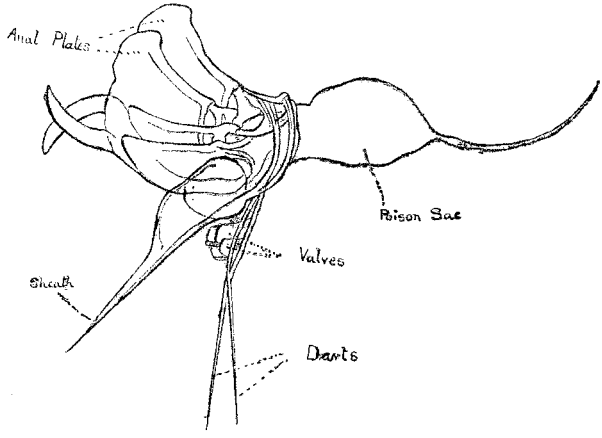


FIG. 35.—STINGING ORGAN OF THE HONEY BEE.

[*From S.S.I.*]

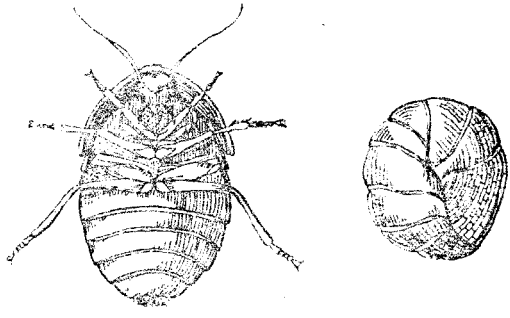


FIG. 36.—A ROLLING COCKROACH.
(*Perisphaeria armadillo*, L.)

[*After B. Museum leaflet.*]

when disturbed, certain offensive secretions which evidently keep off the intruder ; the latter habit is met with among some bugs, beetles, ants, caterpillars, termites, etc. In addition to the various adaptations noted above there is found among insects, as in some other animals also, a remarkable feature called "*Protective resemblance*" —viz., the very close resemblance of the insect to its surroundings. This resemblance to the environment may be in structural peculiarity, in coloration or in both. Excellent examples are to be found among leaf and stick insects, the various bark and leaf infesting beetles, bugs and grasshoppers, the twig caterpillars and surface grasshoppers, butterflies and beetles (figs. 37–39) ; both the form and color are combined in many insects. It may be stated here that color plays a very important part in the binomics of insects and in many forms this colour resemblance to the environment is known as "*Protective coloration*". While in some forms the body color helps the creature to conceal itself, there are other insects which possess color patterns which are very conspicuous in the midst of their environment ; these are known as "*Warning colors*" and are generally possessed by forms which are usually unpalatable or dangerous to their enemies and which by their conspicuous and strong coloration warn their enemies and thereby escape danger. Examples of such forms are some wasps, lady-bird beetles, plant bugs, butterflies and numerous caterpillars.

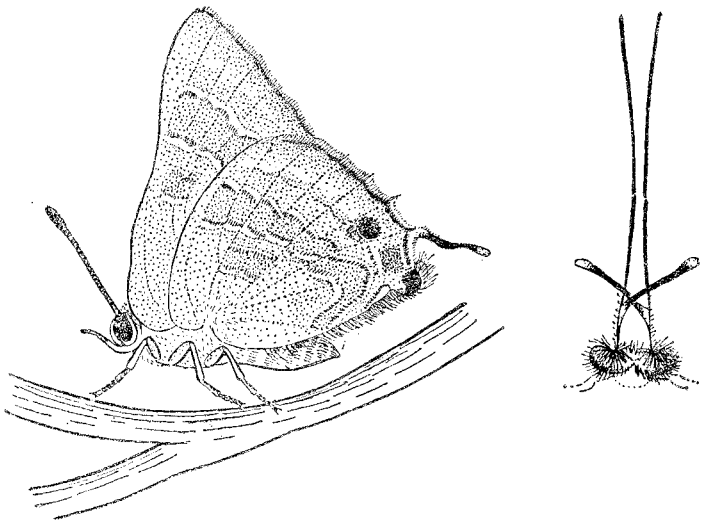


FIG. 37.—THE POMEGRANATE BUTTERFLY.
(Protective attitude showing wingtails and eye spots.)

[*From S.S.I.*]

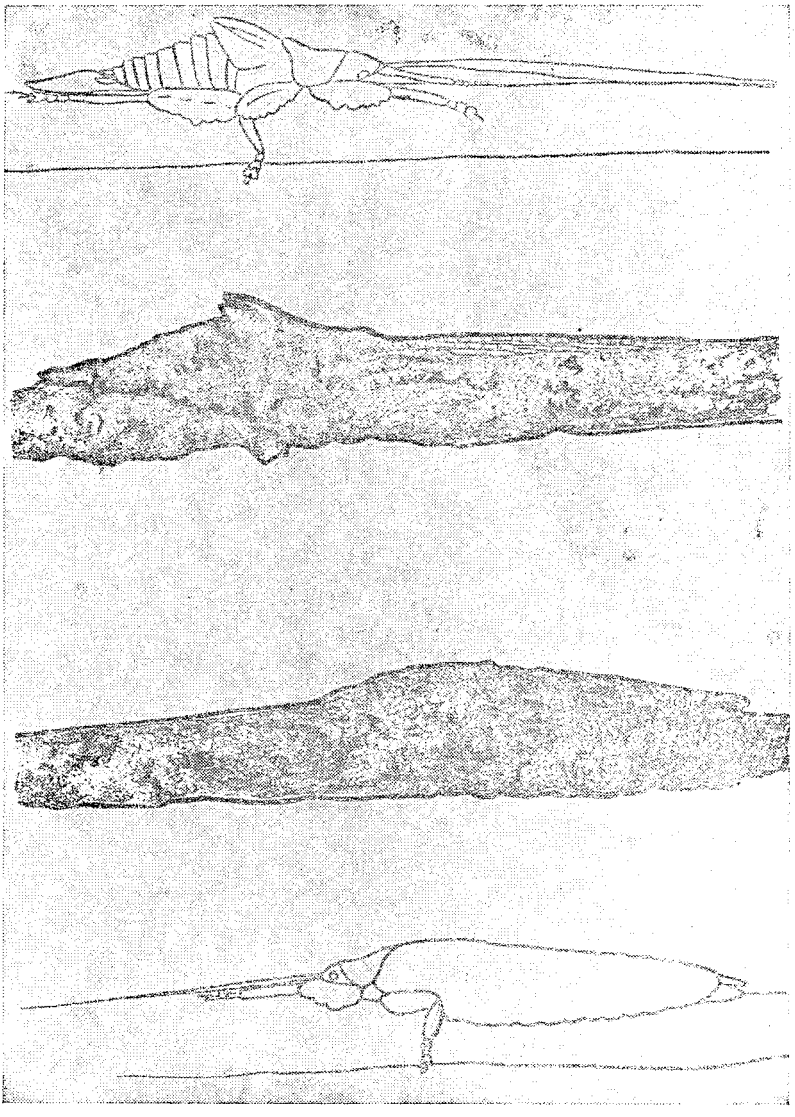


FIG. 38.—PROTECTIVE RESEMBLANCE OF A TREE GRASSHOPPER (*Sathrophyllia*).

[*After Dammerman*]

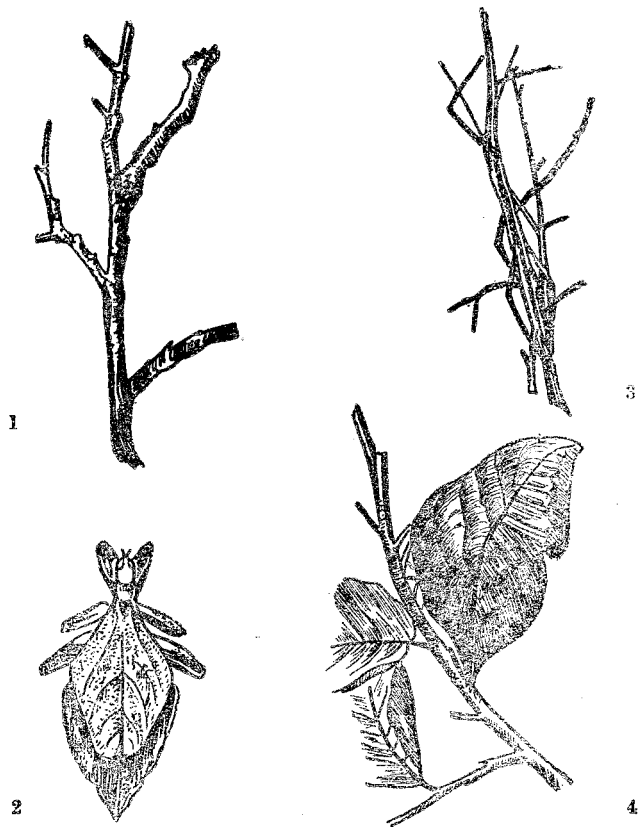


FIG. 39.—PROTECTIVE ADAPTATIONS.

1 Twig caterpillar. 2 & 3 Leaf and stick insects.
4 *Kallima* (leaf butterfly).

[*After Bates.*]

In this connexion a brief reference may be made to the phenomenon known as "*Mimicry*" which is a special form of protective resemblance in which "one species imitates the appearance of another and better protected species thereby sharing its immunity from destruction;" the former is known as the *mimic* and the latter whose external form is copied is called the *model.* In such cases, the insect which mimics is always the weaker and more defenceless of the two and it escapes from its enemies by its close external similarity to a well-protected creature living in the same locality. It has to be specially noted that this mimicry is purly external and does not in any way affect the internal or the unexposed parts of the imitator. Familiar examples of mimicry are to be found chiefly among some butterflies, moths, bugs, wasps and flies (fig. 40).

Among the other methods of protection found among insects may be mentioned the feigning of death when disturbed as in some weevils, assuming threatening postures as in some caterpillars (fig. 41), and the production of some sound and expulsion of some secretions when disturbed as in some beetles, moths, etc.

MIMICRY

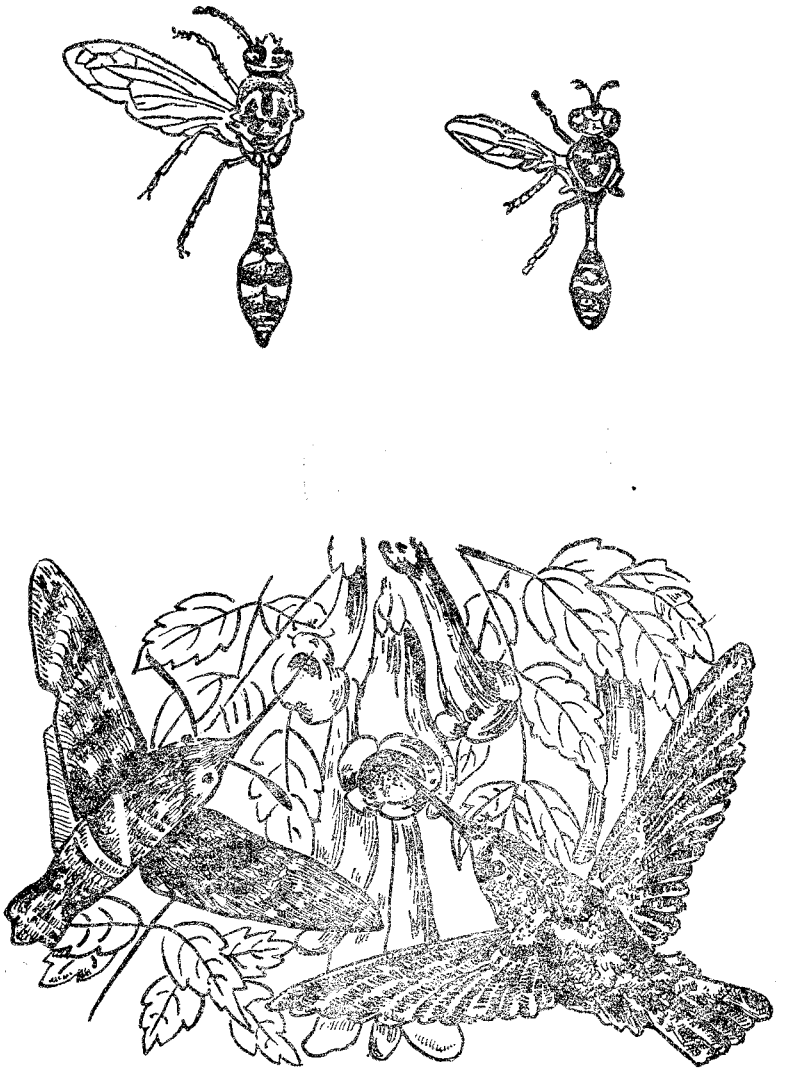


FIG. 40.—INSECT MIMICRY.
1 Wasp and fly. 2 Hawk moth and humming bird.
[1 *From S.S.I.* [2 *From Bates*

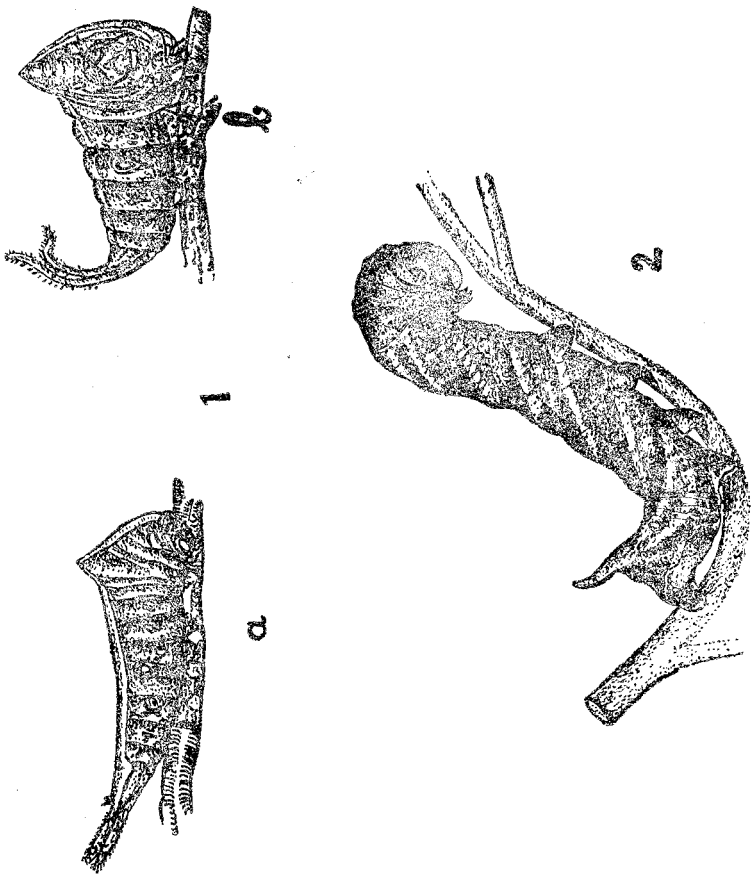


FIG. 41.—FRIGHTENING ATTITUDES OF CATTERPILLARS.

1 *a* & *b* Puss moth caterpillar (*Cerura liturata* W.) [after Poulton].
2 Sphinx caterpillar (*Acherontia styx* W).

Insect behaviour and inter-relations.—As in the case of other animals the behaviour of insects in different ways may be more or less attributed among others to two or three important sources—Instinct, Intelligence and Tropisms. While those caused by the two former are usually results of some internal stimuli, tropic reactions are generally caused by environmental influences. Some of the external factors such as temperature, humidity, light and chemical influences often direct the activities of various insects and the responses of the latter to such external stimuli are usually known as "*Tropisms*" (fig. 42). There are different kinds of tropisms exhibited by different insects; the most important of these are *Chemotropism* or response to chemical stimuli and *Phototropism*-response to light; some of the other tropisms known are *Hydrotropism* (Water), *Anemotropism* (Air) and *Thermotropism* (Heat). In all

these cases the response on the part of the insect to the stimulus will be found either to be positive or negative, i.e., those insects which are attracted towards the stimulus—light, heat, water or chemical are said to be positively tropic while others which shun and move away from the stimulus are said to be negative. A very common example of such tropisms is to be found in the striking phototropism displayed by insects like some moths, cockchafer beetles, winged termites and others flying towards lights at night. Similarly certain flies, moths, etc., are chemotropic being attracted or repelled by the smell of some drugs, oils, flesh, etc. All such tropic reactions to different influences appear to be on the whole adaptative in their results. Speaking of the other two factors in insect behaviour, viz., instinct and intelligence, it becomes very often a difficult matter to distinguish as to which may be classed as instinctive and which as a result of intelligence. As a rule, instinctive behaviour is a reflex act and may be considered even as a tropic or mixture of tropisms. It is generally a kind of adaptive action without any past experience or actual volition, and among animals insects appear to be remarkably instinctive. The selection of a particular plant for egg-laying by a butterfly, the stinging by a

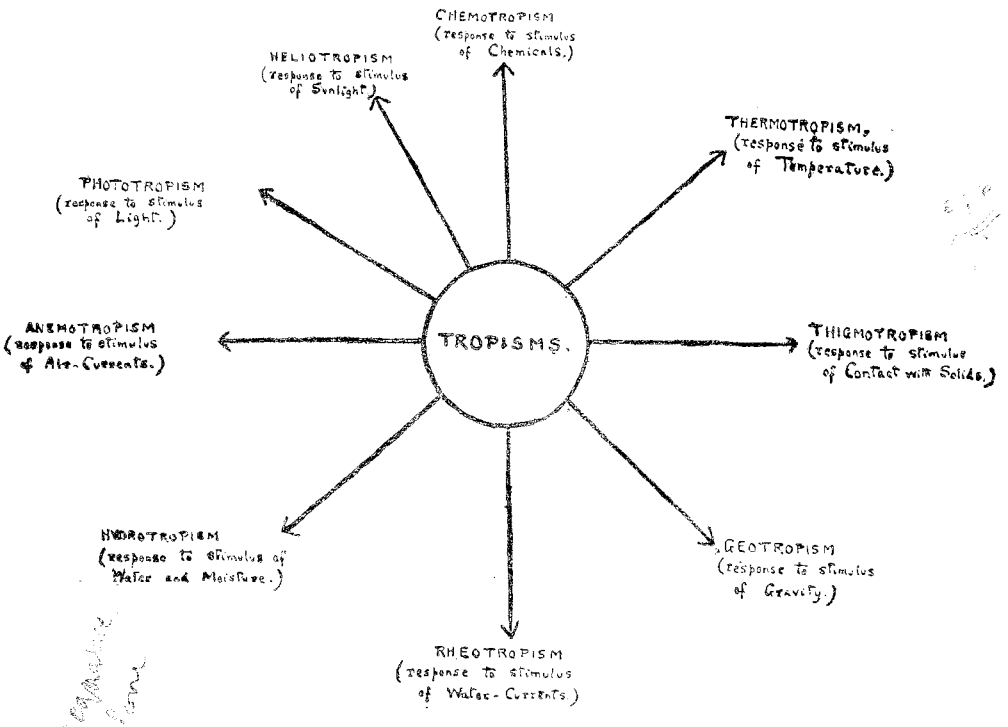


FIG. 42.—TROPISMS.

[*From S.S.I.*]

wasp when disturbed, the hive building of the worker bees and ants are a few of the numerous examples. Some of the actions of certain insects especially ants and wasps often reach far beyond the bounds of what may be regarded as instinct. It is therefore safe to conclude that "while most of the behaviour of insects is purely instinctive there is some reason to believe that at least gleams of intelligence appear in most specialized hymenoptera." In speaking of these phenomena among insects the following paragraphs from Metcalf and Flint may be interesting and not out of place :—

"Insects communicate with each other by effective language, although not by vocal or spoken words. They scout for food, advise others of their own colony when it has been found, and despatch crews of workers to bring it in. They prepare seed beds (fungus gardens) fertilize them with their own excreta, plant them with one particular kind of spores, and crop and distribute the harvest equitably to useful members of the colony. They store food for winter for times of drought, sometimes in the most clever and ingenious ways. They harbour and protect other insects which yield for them a valuable food, much as our cows give milk, and sometimes make shelters or barns in which the 'cows' are confined. They collect the eggs of these, their domestic animals, keep them over winter with as much care as pioneers guard their eggs for hatching or seeds for planting. They work for the common good and readily die in defence of their 'queens' and their homes. They make war by military manouvres that convince the observer of definite purpose and accomplishment. They capture slaves and hold them with apparent ease and in seeming contentment. They organize millions of individuals under the most crowded conditions, without legislative, judicial or executive bodies, so far as we know, yet with such a wholehearted co-operation and efficiency that there is little friction apparent to the observer. Unlike man with his solicitous charity and extravagant care of the individual, even to the point of endangering the race, they are relentless in their destruction or ostracism of injured and useless members of their society. Their behaviour shows unmistakable signs, at times, of pleasure, joy, panic, anger. pain, playfulness. They are cleanly, sanitary and neat in the extreme. They profit by experience. They can be tamed. They exhibit indications of reason, judgment, reflective power, resourcefulness and the ability to make simple plans and carry them out.

"Is it intelligence or instinct. A sane view of the matter probably is that the same mental process which characterises human life have their roots far back in the lower groups of animals. There is no point at which we can divide the animals into two groups and say: on this side of the line are consciousness and intelligence, on the other side the blackness of unconsciousness and inactivity. Insects have made a great speciality of the instinctive type of behaviour, But here and there are glimpses of the same intelligence, reason, memory and forethought, which have made the human race the dominant animal, and even greater ability to organize the harmonious community than has been found anywhere in human experience.

"As Riley has said, if we could put the directing enginery of the human brain in a body like that of the insects, with a hard external shell, at once a defence against external attack and a protection to delicate vital organs, yet allowing free play for every desirable movement; with a breathing system that is diverse and multiple and therefore less liable to get out of order than ours; with six hands and feet instead of four, with a powerful venomous sting for defence; with the power of flight independent of unreliable machinery; with the enormous industry of an organization in which each caste or profession is determined at birth and there are apparently no labour strikes, legislative filibusters or revolutions, but the greatest of self-sacrifice and loyalty to the common weal, with a reproductive system capable of producing young at the rate of one per second almost indefinitely yet provided with efficient birth control when needed; in such a picture we have a creature for which man would be but a poor competitor."

Inter-relations of insects.—The following are some of the more important categories of insects among which we find their various inter-relations well displayed *Social insects, Parasites* and *Predators* :—

Social forms.—Among insects the typical groups which lead a social or communal life are the bees, ants, wasps, and the termites or white ants (fig. 43). The various adaptations, structural peculiarities and physiological traits found among the individuals of these social insects living in colonies form a most absorbing and fascinating study in the animal kingdom. The different individuals and castes found among these such as workers, soldiers, drones, queen, etc., etc., the remarkable organisation and discipline among them, the division of labour and the wonderful co-operation in working for their common good are some of the important characters which resemble or even go beyond the features of some of the well organized human societies. We shall have occasion to refer to some of these social insects later when we deal with useful insects.

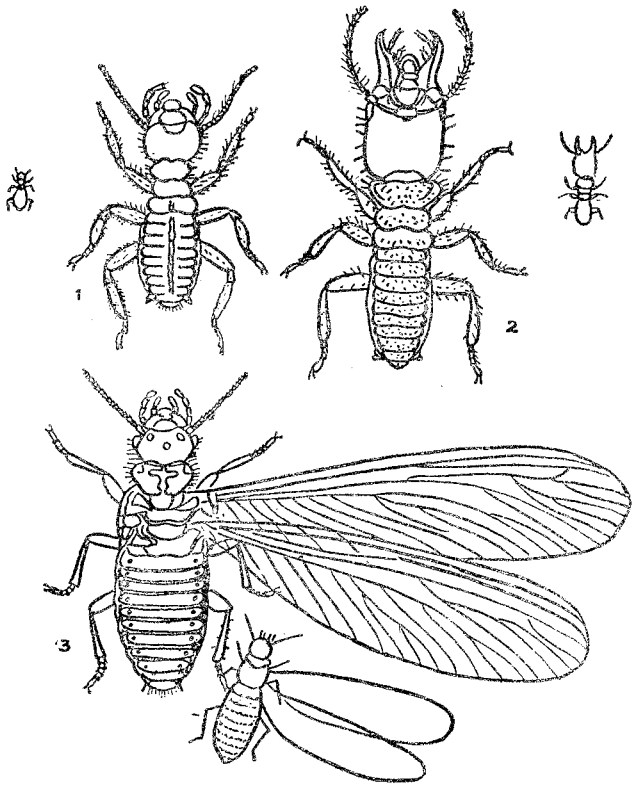


FIG. 43.—TERMITES—CASTES.
(*Odontotermes horni*)

1 Worker, 2 Soldier. 3, Winged adult.

[*After Bugnion.*]

Parasites.—Those insects which depend for their lodgings or sustenance or both on other animals are known as Parasites. In this case, the animal which harbours the parasite is the host; the parasite in these cases is invariably smaller in size than the host. The hosts of insect parasites include higher animals, man and also insects, and it is with the last that we are here concerned. Numerous insects pass their early developmental stages inside the bodies of other insects as internal parasites and most of these are found in the groups of flies and wasps. The adult female parasite usually lays its egg on or inside the body of its insect host (fig. 44) the egg hatches into a larva which feeds on the internal contents of the host's body, pupates and emerges as an adult parasite; in the meanwhile, the host, though it survives the attack for a time, gradually dies. Frequently this parasitic habit of some insects becomes economically important in many cases where the hosts happen to be pests of economic importance. We have in this way several wasps and flies acting as natural enemies in nature and controlling many caterpillar and beetle pests of crops like paddy, millets, legumes, cotton, etc. (fig. 45). The peculiar

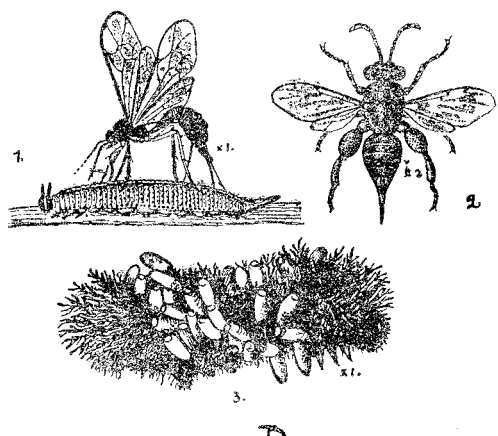


FIG. 44.—PARASITIC WASP.

1 Wasp laying egg on caterpillar.
2 Another wasp.
3 Parasitic cocoons on caterpillar.

adaptations and the breeding habits of some of these parasitic insects are very remarkable and varied in nature. Examples are not however, wanting of insect parasites being, in their turn, attacked by other parasitic insects.

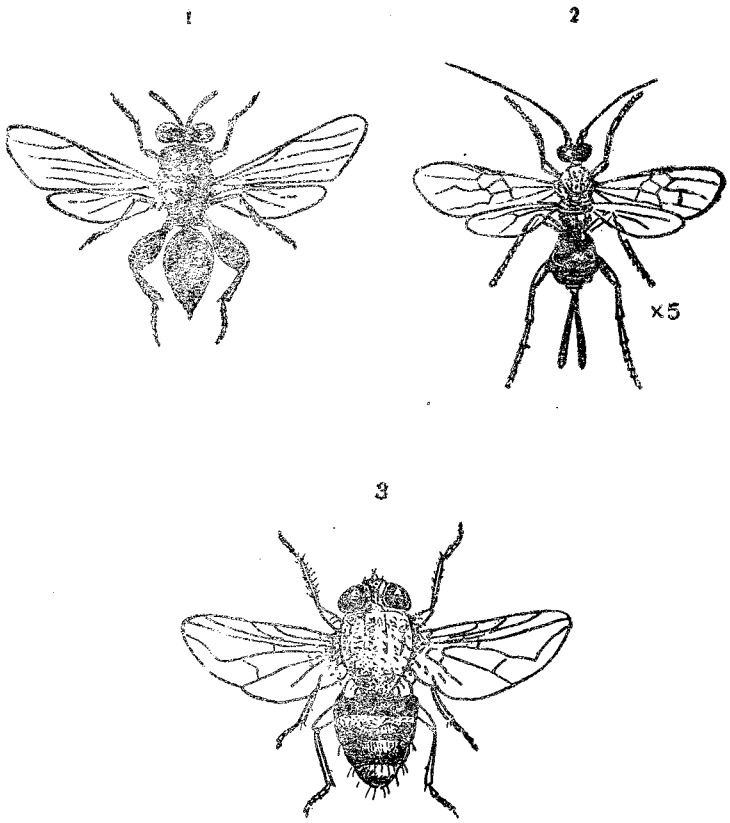


FIG. 45.—PARASITIC WASPS AND FLY.

1 Chalcid wasp (*Stomatoceras ayyari* G).
2 Braconid wasp (*Campyloneurus ceylonicus*, C).
3 Tachinid fly (*Sturmia bimaculata*, H).

Predatory insects.—This group of insects plays a somewhat different role from parasites; they act as hunters capturing their insect victims and feed on them. The only marked difference between parasitism and predatory habits is that in the former the death of the victim is a slow and gradual torture while in the latter the death of the prey almost immediately follows its capture by the predator. Well-known examples of predatory insects are beetles of different kinds, including chiefly the tiger, ground and lady-bird beetles, the dragon flies, robber flies, ant lions, the mantis, some stink bugs, the giant water bug, hornets and some aquatic beetles (figs. 46–49). Of these, the lady-bird beetles form one of the few predatory groups which have an economic importance, since some of them are found very effective as natural enemies of some bug pests of plants. Some hymenoptera sting and paralyse their victims, and store them as food for their young ones; these are

known as "stinging predators"; well-known examples are the potter and digger wasps which attack caterpillars, spiders, bugs, flies, etc.

In addition to these important inter-relations among insects as parasites, predators and social forms, we find instances of insects which live as associates, messmates, guests, slaves or friends with one another; striking examples are those insects which live in the nests of termites and ants called *Termitophila* and *Myrmecophila*.

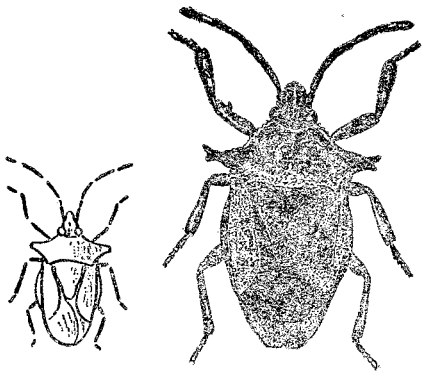


FIG. 46.—PREDATORY STINK BUG.
(*Canthecona furcellata*, W.)
[*From S.S.I.*]

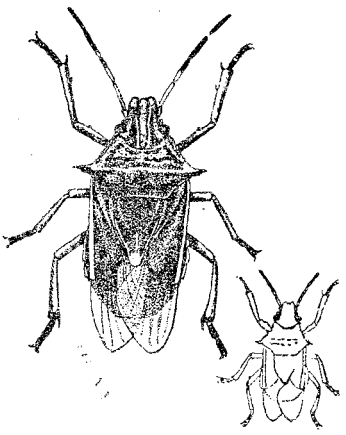


FIG. 47.—PREDATORY STINK BUG.
(*Andrallus spinidens*, F.)
[*From S.S.I.*]

Insects in their relation to other organisms.—From the inter-relations among insects, we proceed to study the relations of insects with other organisms; these latter include the members of the vegetable kingdom and all the other animals besides insects.

Insects and plants.—As stated before, when referring to the food of insects, the great majority of the latter depend for their food on plants. Apart from this primary relation between insects and plants, several insects exhibit closer affinities with the latter in other ways; such are the gallformers, flower pollinators, weed killers and vectors of contagious plant diseases. Well-known examples of gall makers among insects are to be found among wasps, flies and thrips. The study of the part played by some insects as agents in pollinating flowers of various kinds is a very interesting and fascinating subject. Many striking and marvelous adaptations are often met with among insects which help them in performing such remarkable functions; some flowers are particularly found adapted for visits of special insects without which the plants do not thrive well (fig. 50). It is also known that several plants of economic value, especially some fruit trees, depend a great deal on the activities of

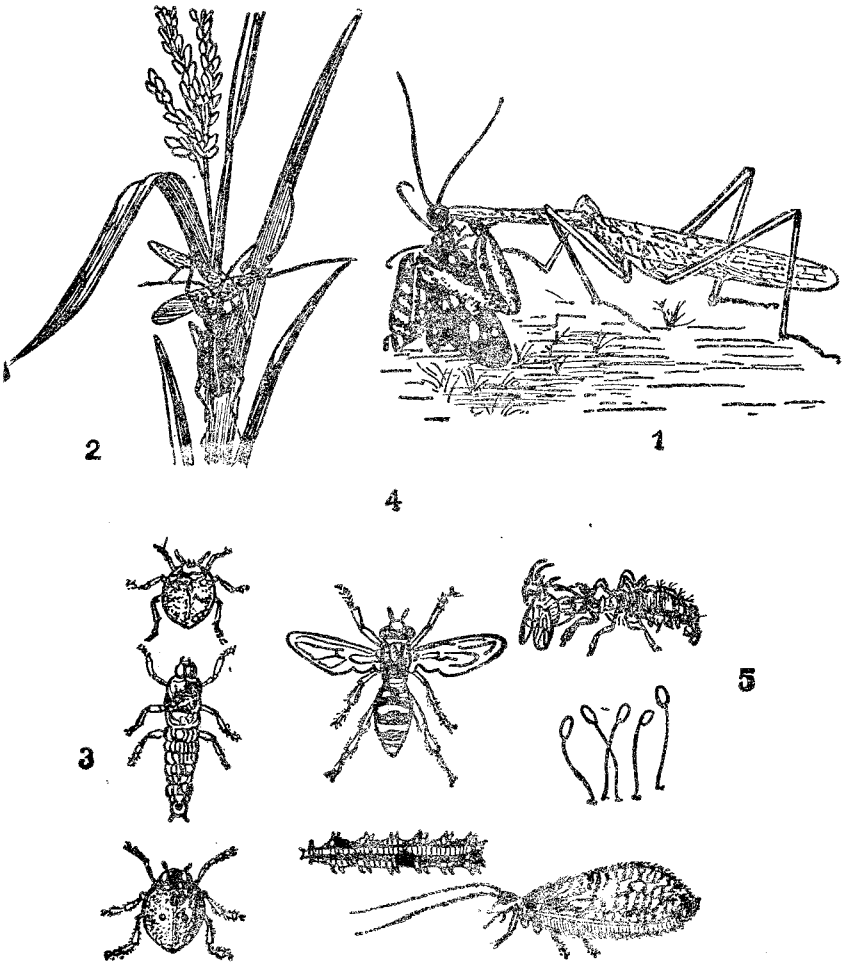


FIG. 48.—PREDATORY INSECTS.

1 Mantis.
2 Tiger beetle.
3 Lady-bird beetles.
4 Hover fly.
5 Lace wing fly stages.

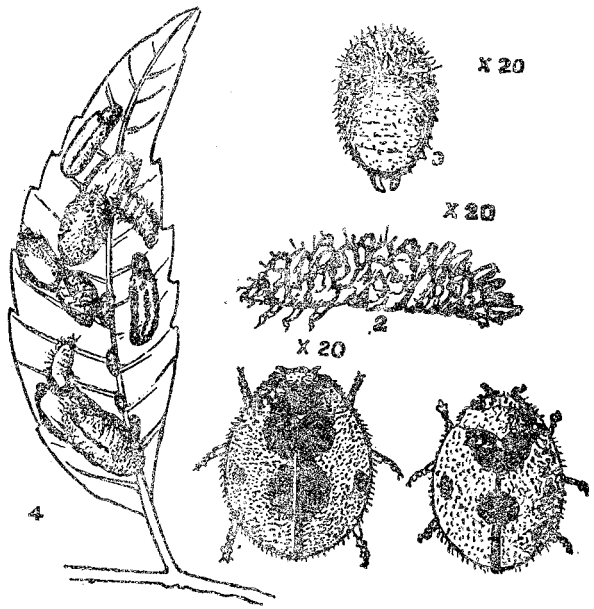


FIG. 49.—PREDATORY LADY-BIRD FEEDING ON SCALES.
(*Scymnus coccivora*, R.)
1–3 Stages of beetles. 4 On scales.

some insect pollinators for a good crop of fruits ; the fig pollinating wasp (*Blastophaga*) is a very well-known example (fig. 51). Similarly some insects are found useful as weed-destroyers, scavengers, etc. Recent studies in Botany and Plant Pathology have revealed the fact that some plants often suffer from maladies which are neither caused by fungi nor insects and these are now known as " Virus " diseases ; those noted on sugarcane, tobacco, chillies, etc., are called by some as *mosaic*. A virus according to K. M. Smith is an agent below or just on the border line of microscopic visibility that causes disturbance of the functions of living cells (of plants) and is itself regenerated in the process. In the case of some of these *Virus* diseases it has been discovered that some insects act as vectors or carriers of these infectious diseases—(like plant lice, thrips, etc.). Rare instances are also known of some flowers which are attracted by some male wasps which mistake the flowers for their mates and even exhibit the sexual act. It may also be noted that some plants are adapted in different ways to trap insects known as insectivorous plants ; examples are the Sundew (*Drosera*) and Venus Fly trap (*Dionæa*).

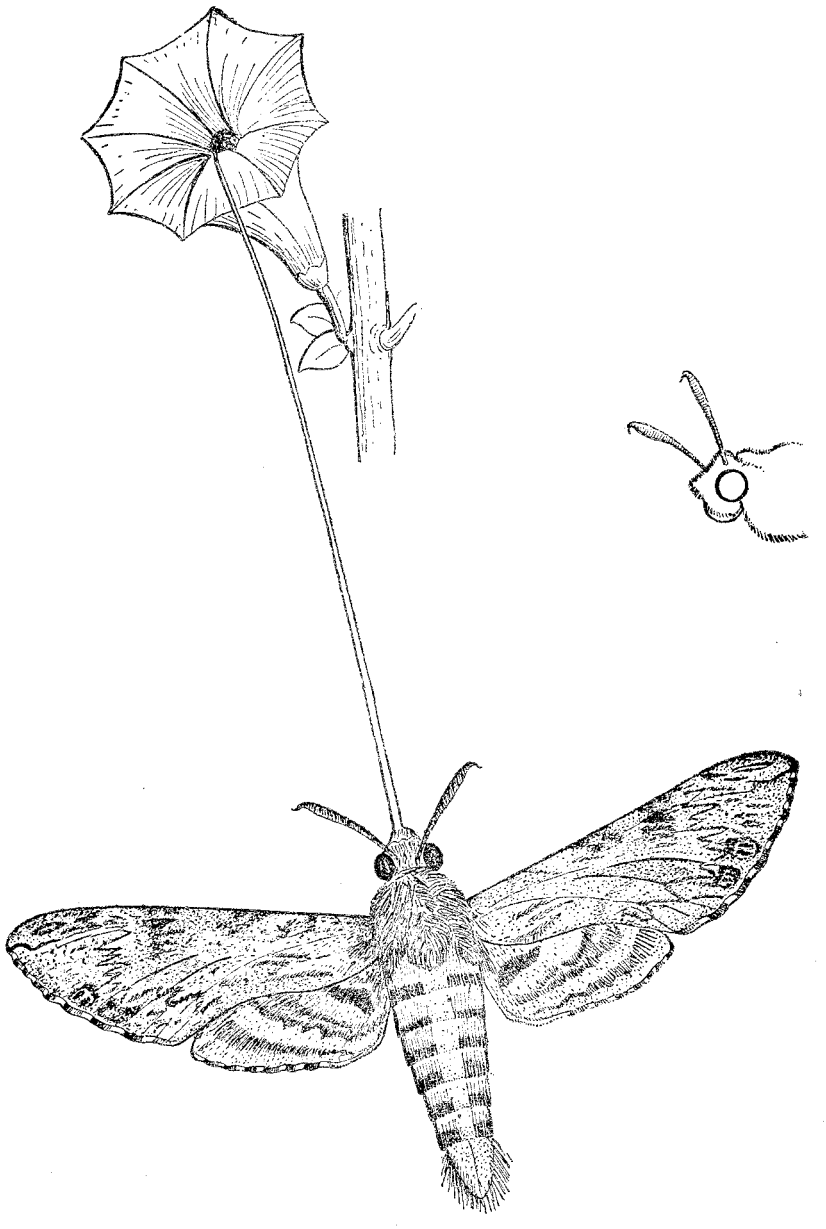


FIG. 50.—HAWK MOTH FEEDING.
(*Herse convolvuli.*)

[*From S.S.I.*]

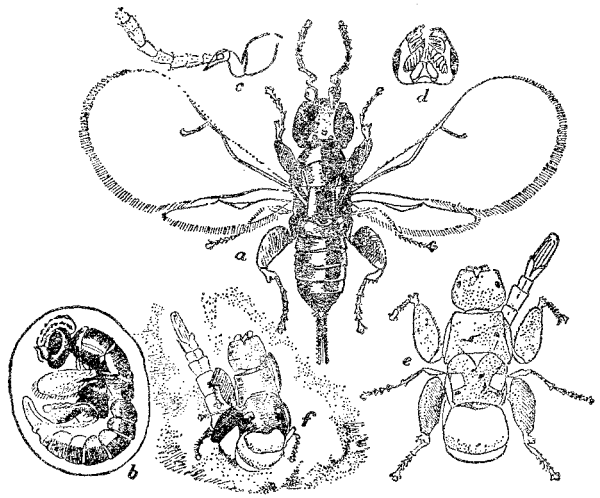


FIG. 51.—FIG INSECT (*Blastophaga*).

a Adult female.
b Female before emergence from gall.
c Feeler of female.
d Head of female.
e & *f* Adult males.

[*From U.S.A. Bulletin.*]

Insects and other animals.—The relations of insects to other animals are equally varied. As stated before, just as some insects are carnivorous and predatory on other small forms of life, some others are parasitic on many other animals, especially on the warm blooded higher animals such as birds and mammals including man. Well-known examples are the many blood sucking flies, fleas, lice, mosquitoes, etc., some of which are even carriers of disease germs (see p. 411). Many insects in their turn form food of numerous higher animals especially birds and mammals and these latter (*Entomophagous*) often act as their natural enemies. There are forms among insects which act also as scavengers removing dead animals and vegetable matter and cleaning the earth's surface; such are the carrion beetles, dung rollers, flesh and other flies, ants, etc. Since the different relations which insects have with various plants of economic importance, man and his belongings and their good or bad effects form the main theme of this volume it will be quite sufficient in this place just to refer to this aspect of the subject.

Insect distribution and dispersal.—Insects are found all over the world from the frozen polar regions to the burning equatorial areas, and they are the most widely distributed of all the land animals. Many insects are known to be found all over the world (*cosmopolitan*) while many others have restricted distributions. Among cosmopolitan insects the well known ones include our household forms such as cockroaches, the rice weevil, the pulse beetles, th3 meal-worms, etc.; among others which are at present found cosmopolitan are the gram moth (*Heliothis*), the potato moth (*Gnorimoschema*), the sweet potato weevil (*Cylas*) and the cabbage diamond

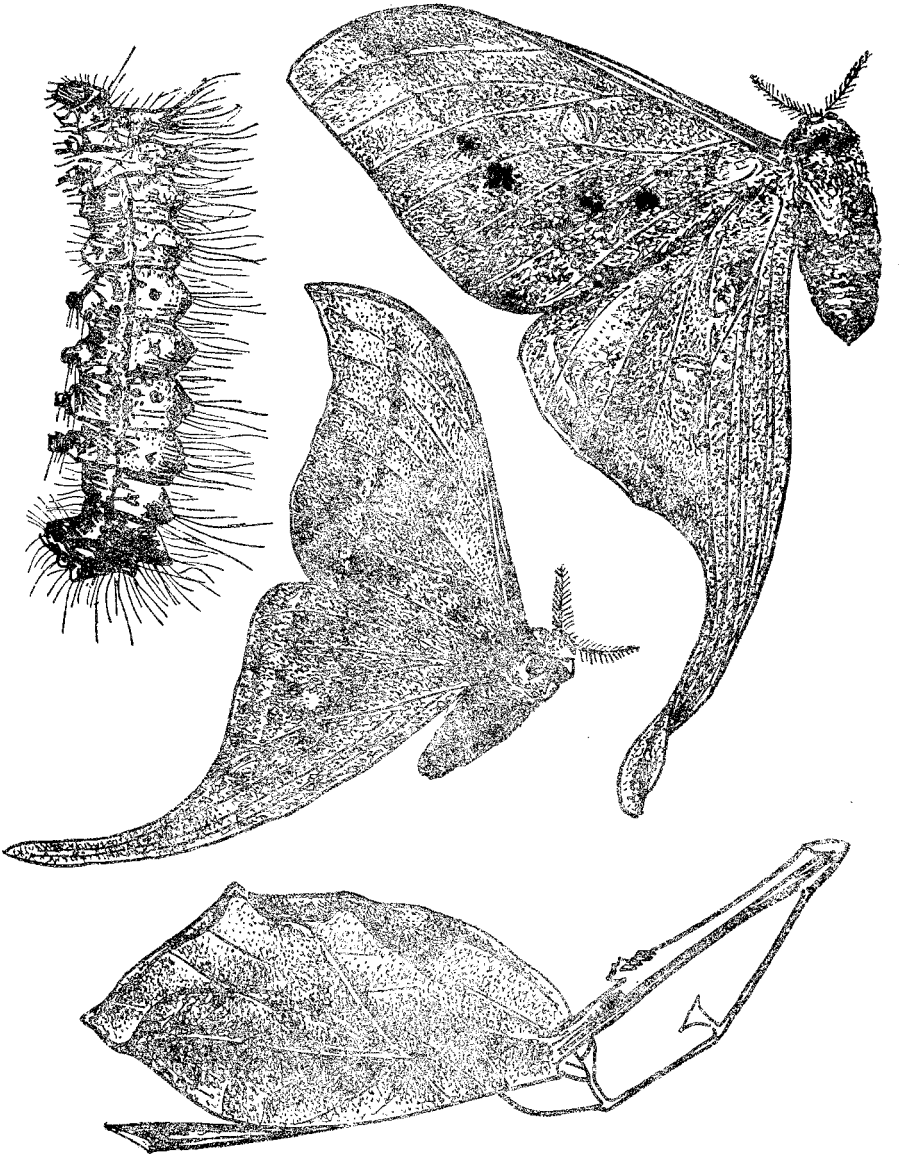


FIG. 52.—THE MOON MOTH, ITS CATERPILLAR AND COCOON
(*Actias selene, Hb.*)

[*From I.M. Notes.*]

back moth (*Plutella*). In the same way there are many other insects special to each particular tract or country, and this distribution may be attributed to various causes such as climatic differences, difference in vegetation and natural barriers like seas, mountains, etc., which prevent the dispersal of insect forms from one tract to another. Some insects like saw flies, the cabbage butterfly, etc., are confined to the temperate regions, while others like fruit flies, paddy insects, etc., are tropical forms and some forms occasionally have a tendency to migrate, like locusts and some butterflies, etc. Nowadays however, due to the existence of various convenient and rapid facilities for the transport of insects and plants from one country to another, it will be difficult to state in course of time the exact native homes of the various insects and plants inhabiting the different parts of the world; nor is such a dispersal found quite beneficial in all cases, at least in the interests of man, as may be seen from the legislative measures adopted nowadays by many advanced countries to prevent such indiscriminate imports of undesirable plants and animals.

Size and numerical strength of insects.—The size of living insects varies from a third of a millimetre to six or seven inches in length, and the wing expanse of the flying forms ranges from one-sixth of an inch to as much as a foot or more. Some of the largest insects known are the tropical wild silk moths (*Attacus*, *Actias*, fig. 52, *Antherea*, etc.) which have a wing expanse of ten to twelve

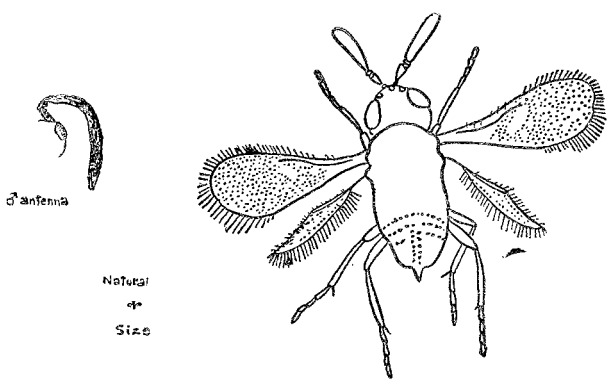


FIG. 53.—A VERY MINUTE CHALCID WASP

[*From S.S.I.*]

inches. Other giants among insects are some of the stag, dung and longicorn beetles, grass-hoppers and stick insects; some of the wood boring larvæ also reach five or six inches in length. The smallest of insects are to be found among some beetles, flies, leaf-hopper bugs, ants and parasitic wasps (fig. 53). "Some insects

are smaller than the largest Protozoa and some others are larger than the smallest Vertebrata." The apparent defect in the size of insects as compared with that of other invertebrate animals is more than made up by their numerical strength among animals. The number of known living species of animals is roughly estimated to be about nine hundred thousand, and of this number, seventy-five per cent are insects. The rough diagram given below (fig. 54) gives us an idea of the comparative sizes of the important groups included in the animal kingdom. Taking the distance between the finger tips of our outstretched right and left arms across our chest to represent the size of the whole animal kingdom, the divisions marked therein give us the comparative size of each important animal group. It will be seen how the group of insects occupies a distance stretching from the elbow of one arm across the chest and the two shoulders right up to the tip of the large finger of the other arm, thus showing its enormous size when compared with all other animal groups.

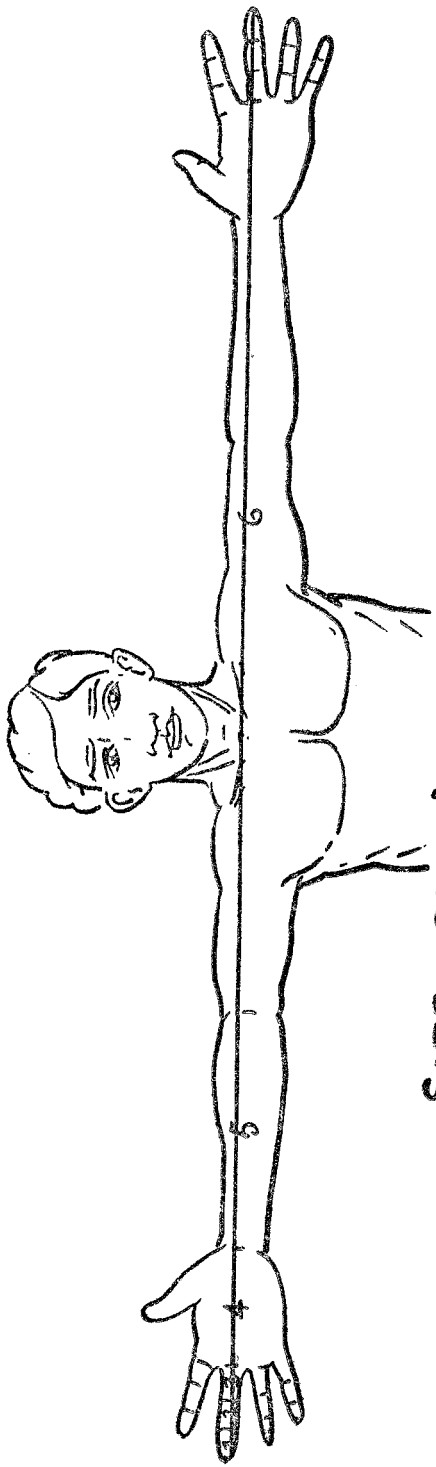


FIG 54.—SIZE OF ANIMAL GROUPS.

CHAPTER VI.

Insect Classification.

Importance of and necessary for insect classification—Factors in classification. Main groups of insects with familiar and important examples.

In the study of any group of animals, and especially of one of the dimensions of the class Insecta, it will be found quite essential to know exactly the relative position and name of the individual species we may refer to from time to time, so that we may be in a position to know as to what it is we are talking about and what is not. For, it very often happens that insects which might appear similar in appearance may possess entirely different habits and life histories. To avoid possible mistakes, it is always safer to know exactly the name, position and relation of each insect as far as possible. It will be worthwhile quoting the following remarks of Spence made in 1834: "Knowledge as to the structure, habits and economy of insects ought to be the grand and ultimate aim of the entomologists; but this knowledge can be neither acquired nor diffused without systematic classification, which is the dictionary that must enable us duly to read the great book of Nature." As is evident, it is possible to divide insects in various ways based on different criteria such as structure, habits, behaviour, etc.; but the system generally used by Entomologists is mainly based on the structural features of the adult insect, especially of the wings and mouth parts and on the type of metamorphosis insects undergo during their developmental stages.

Insect divisions.—Based on these main criteria the group of insects which is known as the class *Hexapoda* was divided originally by the famous naturalist Linnæus into seven subdivisions called Orders. Until recently, writers like Sharp and Lefroy have been adopting a nine order classification. However, later studies made by modern Entomologists on the affinities of the members these original orders and on newly discovered forms have shown that the class is capable of being divided into two dozen or more distinct orders as shown below :—

MAIN DIVISIONS AND ORDERS OF THE CLASS INSECTA.

Sub-Class A. **APTERYGOTA**—

Insects without wings at any stage—Primitive forms—No marked metamorphosis—Small creatures—Includes three orders formerly grouped as Aptera.

Order—

1. **Thysanura.**
2. **Collembola.**

A third order of Apterygota—*Protura*—Recognized by some is omitted in this arrangement.

Sub-Class B. **PTERYGOTA**—

Insects with or without wings but showing relationship or descent from winged forms; Metamorphosis, partial or complete, includes two divisions as below :—

Division A—

EXOPTERYGOTA (Hemimetabola)—Insects in which the wings develop from outside; no pupal stage in development; nymphs with compound eyes.

Order—

3. Orthoptera.
4. Dermaptera.
5. Thysanoptera.
6. Hemiptera.
7. Homoptera.
8. Anoplura.
9. Isoptera.
10. Mallophaga.
11. Odonata.
12. Embioptera.
13. Psocoptera (Corrodentia).
14. Plecoptera.
15. Ephemeroptera.

Division B—

ENDOPTERYGOTA (Holometabola)—Insects developing wings from within and with a pupal stage during development; larvae without compound eyes.

Order—

16. Neuroptera.
17. Mecoptera..
18. Trichoptera.
19. Coleoptera.
20. Strepsiptera.
21. Lepidoptera.
22. Diptera.
23. Siphonaptera (Aphaniptera).
24. Hymenoptera.

It will be seen from the above that at present about two dozen distinct insect orders are recognized. The marked increase in the number of orders from the original number is chiefly due to more

thorough and detailed studies especially of the numerous insects that were originally dumped into a heterogenous order under the name *Neuroptera* which has, on this account, been split up into many different groups. In fact, almost all the groups of the old nine order system excepting the *Hymenoptera, Lepidoptera* and *Thysanoptera* have been re-arranged. Each of the various insect orders is again subdivided into families, and each family includes a number of genera and species. A very brief account of the main distinguishing features of these orders, especially the economically important ones with familiar examples from each is added below :—

1. *Thysanura.*—This group includes small insects which are primarily wingless and exhibit no metamorphosis. The head has long feelers and the mouth parts are adapted for chewing ; the body is usually soft and often covered with scales or hairs with the abdomen having ten or more segments. The common household insect—the silver fish, Lepisma (Fig. 347) is a typical example of this order. It has a flattish soft scaly body with three tail processes.

2. *Collembola.*—These are minute forms known as 'spring tails' and 'snow flies'. In fundamental features like absence of wings and metamorphosis having chewing mouth parts they are similar to the Thysanura. They differ from the latter in having only six abdominal segments and possessing a characteristic forked appendage on the first abdominal segment. Very little is known of these insects from India though some species of *Collembola* are known to be pests in Europe and other countries—especially on edible fungi (mushrooms). One species (*Isotoma minos*, D.) (Fig. 55) has been noted by the author in damp situations in parts of South India.

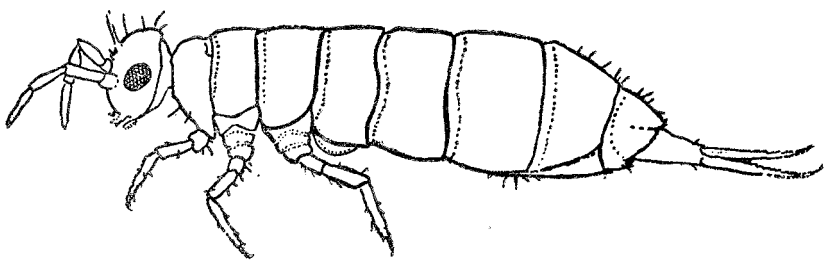


FIG. 55.—A SOUTH INDIAN SPRINGTAIL (*Isotoma minos*, D) (magnified).

3. *Orthoptera.*—All the insects of this group have the typical biting mouth parts and the metamorphosis is a gradual one, the young ones resembling the parent in all essential structural features and habits. The typical winged forms have two pairs of wings of which the front pair is narrow, straight and thickened, while the hind pair is thin, membranous and kept folded like a fan under the front wings. The antennæ are generally long and conspicuous ; the prothorax is large and forms a prominent shield. The legs are large and often the hind pair is stout and adapted for leaping. The

anal region of the abdomen bears some processes called *cerci* in some species and some female insects have a well developed and conspicuous ovipositor. The order is a fairly large one and includes some large sized insects like big grasshoppers and long stick insects. The important families included in it are the cockroaches (*Blatidæ*), grasshoppers, locusts, etc. (*Acrididæ*), the long horned grasshoppers (*Tettigonidæ*), the mantises (*Mantidæ*), the stick and leaf insects (*Phasmidæ*) and the crickets (*Gryllidae*). Of these different families, the Acridiidæ, the Gryllidæ, the Locustidæ and the Blattidæ include forms which have some economic importance as injurious insects. The rice grasshopper (*Hieroglyphus banian*, F.), surface grasshoppers of different kinds (*Chrotogonus* spp.), the wingless Deccan grasshopper (*Colemania sphenarioides*, B.), the field and house crickets (*Gryllus* spp.) and the household cockroaches (*Periplaneta* and *Blatta* spp.) are well known among them.

4. *Dermaptera.*—This order which is closely allied to Orthoptera includes the *Earwigs* easily recognized by the peculiar anal forceps and their curious hind wings. The earwigs have not so far exhibited any striking economic importance in South India.

5. *Thysanoptera.*—The insects of this order—popularly known as *thrips*—are active, soft bodied, minute forms ranging between 1/20 and 1/4 of an inch in size. They are chiefly characterized by the wings having fringes along the margins which gives the order its name—Thysanoptera (fringe winged forms). They have a type of mouth parts which is adapted for lacerating the soft parts of plants and sucking the juice, a stage more or less intermediate between the chewing and sucking types. The arrangement of these parts is not also symmetrical in them, one of the mandibles being considerably reduced or wanting. The winged forms always have four wings with the characteristic lateral fringes. The insects undergo only a partial metamorphosis though the later nymphs pass through a quiet pupa-like stage before assuming the adult condition. Thrips are usually plant feeders and are generally found inside flowers, on tender foliage, under bark and often inside leaf and shoot galls. Some of these insects are well-known crop pests. Well known forms are the onion thrips (*Thrips tabaci*, L.), the chillies thrips (*Scirtothrips dorsalis*, H.), the rice thrips (*Thrips oryzæ*, W.), the grape thrips (*Rhipiphorothrips cruentatus*, H.), and the ground-nut thrips (*Heliothrips indicus*, B.).

6. *Hemiptera or Rhynchota.*—This order and Homoptera include various kinds of insects known popularly as bugs, which are chiefly characterized by the presence in all their stages of life of suctorial mouth parts forming a piercing proboscis and by the incomplete metamorphosis in development. The order *Heteroptera* includes such of those bugs which have the forewings half horny and half membranous (hence also known as *Hemiptera*); when at

rest the wings remain folded on the back. This group includes numerous plant bugs, especially those with stink or scent glands. Familiar and economically important families are the stinking plant bugs (*Pentatomidæ*) including the green plant bug, the lablab bug, the cabbage bug, the paddy striped bug and the jasmine bug; the families of large sized leaf bugs (the *Coreidæ*, the *Lygeidæ* and the *Pyrrhocoridæ*) including the rice bug, the dusky and the red cotton bugs; the lace-wing bugs (*Tingidæ*) including those on plantain, brinjal, ocimum, etc.; the predatory assasin bugs (*Reduvidæ*), the mosquito bugs (*Miridæ*) including the destructive cholam earhead bug, the betelvine bug and the tea mosquito; aquatic bugs of different kinds known as water boatman, giant water bug, water scorpions, etc. (*Belostomidæ, Nepidæ, Notonectidæ* and *Corixidæ*) and the degenerate wingless parasitic bed bugs (*Cimicidæ*).

7. *Homoptera.*—These insects form an equally big group which includes numerous families. With a few exceptions, the great majority of these insects are comparatively smaller in size than the Heteroptera and many of them are aberrant and degenerate in structure—some without wings, some with one pair of wings, some fixed in the adult condition and so on. These are different from the Heteroptera particularly in the structure of the wings. In the winged Homoptera these organs are throughout of a uniform leathery or membraneous structure and they generally remain sloping, roof like over the abdomen. The head is not as clearly marked off as in the Heteroptera, being bent and placed more or less between the front legs. The sub-order includes some well-known families of economic importance; the important ones are leaf hoppers (*Jassidæ*) found on paddy, mango, cotton, etc., the cane fly family (*Fulgoridæ*), the spittle insects (*Cercopidæ*), the tree hoppers (*Membracidæ*), the jumping plant lice (*Psyllidæ*), the white flies (*Aleurodidæ*), the plant lice (*Aphididæ*), the scale insects and mealy bugs (*Coccidæ*) and the singing Cicadas (*Cicadidæ*).

8. *Anoplura.*—These are wingless parasitic insects which live as blood-sucking forms on higher animals and man. They include the human and cattle lice. (*See* Chapter **XX**.)

9. *Isoptera.*—This includes the notorious white ants or *Termites* which are well known as social insects living in colonies and exhibiting remarkable differences among their individuals and in their habits. (*See* p. 397.)

10. *Mallophaga* (*Bird lice*)—These are small flat wingless forms about 1/8″ long. They are found on the bodies of domestic birds like fowls, ducks, turkeys, etc., and these are different from the sucking lice on domestic animals, monkeys and man (*Anoplura*) since they have chewing mouth parts and do not suck blood.

11. *Odonata.*—This order includes the easily recognizable dragon flies which are commonly found flying in the vicinity of ponds and streams catching and feeding on small animals. These

have large heads with chewing mouth parts and four equal-sized wings which are thin and well supplied with nerves. The young ones of these creatures are aquatic in habits.

12. *Embioptera.*—Very small dark delicate insects, wingless or with four equal sized wings with few veins. The prothorax is small while the meso-and metathorax are long. These insects are rarely noted and are not of any economic importance. Some of them live in silken tubes.

13. *Psocoptera* (*Corrodentia*).—This group includes the book lice which are very minute delicate insects often found running about among old books, papers, pictures and occasionally causing some damage to them.

14. *Plecoptera.*—These known as 'Stone flies' are generally found near streams and ponds. They have four wings and chewing mouth parts. The larvæ are aquatic.

15. *Ephemeroptera.*—These are known as 'May flies', they really have two or three long many jointed tails. They are found flying in swarms and attracted to lights. The nymphs are aquatic in habit.

16. *Neuroptera.*—This name under which a variety of insects were grouped until recently has now become restricted to include only the insects known as *ant lions*, *lace wings* and forms closely allied to these. These are predatory in habits and do some beneficial work by feeding on plant lice, etc. They have very delicate lace like wings. The whitish eggs of these lace wing flies are generally found in slender rows on leaves of different cultivated plants. The ant lions are the creatures which make funnel shaped traps along sandy tracts to entrap small creatures for food.

17. *Mecoptera.*—These are seldom noticed insects and are known as 'Scorpion flies' because of the peculiar swollen and upturned tip of the abdomen in the well known forms of the order (*Panorpidæ*). These are carnivorous in habits and are not of any marked economic importance.

18. *Trichoptera.*—In this order are included small moth-like forms commonly found near tanks, streams, etc., and known as 'Caddis flies'. They are usually less than an inch in length and have four wings; the larvæ which are aquatic in habits cover their bodies with curious cases. These insects form the main food of fishes in most places.

19. *Coleoptera.*—As far as we know, the order *Coleoptera* (Beetles) is the largest and includes more known forms than any other order of insects. The structure of the wings in these insects is quite characteristic of the members of this order. The front pair of wings known as the *elytra* are hard and thick in structure and serve as a sort of sheath or envelope for the thin, membranous folded lower wings. When at rest, the inner margins of the two elytra meet along the median dorsal area in a straight line. The lower wings function as the real organs of flight and, during

flight, the front wings are merely kept stretched outside on each side. The mouth parts are of a distinctly mandibulate type as in the Orthoptera, though in the beetles called 'Weevils' the parts are drawn forwards into a beak or snout. All Coleoptera pass through a complete metamorphosis. Though similar in these fundamental features, we find numerous variations and structural peculiarities among beetles. The order includes numerous families, of which some are of very great economic importance. More important of such families are the rose chafers (*Melolonthidæ*), the palm beetles (*Dynastidæ*), the lady-bird beetles (*Coccinellidæ*) many of which are beneficial, the flat-headed borer beetles or jewel beetles (*Buprestidæ*), the round-headed borer beetles or longicorns (*Cerambycidæ*), the blister beetles (*Meloidæ*), the pulse beetles (*Bruchidæ*), the numerous leaf beetles (*Chrysomelidæ*), the well-known snout beetles or weevils (*Curculionidæ*) and the bark and shot-hole beetles (*Scolytidæ*). There are numerous other families which are of very minor importance from an economic point of view. The palm weevil (*Rhynchophorous ferrugineus*, F.), the rice weevil (*Sitophilus oryzæ*, M.), the fruit trees stem borer (*Batocera*), the pumpkin beetles (*Aulacophora* spp.),the rice hispa (*Dicladispa* (*Hispa*) *armigera*, Ol.), the grape flea beetle (*Sceledonta strigicollis*, M.), and the epilachna beetles (*Epilachna* spp.) are some of the notorious beetle pests in South India.

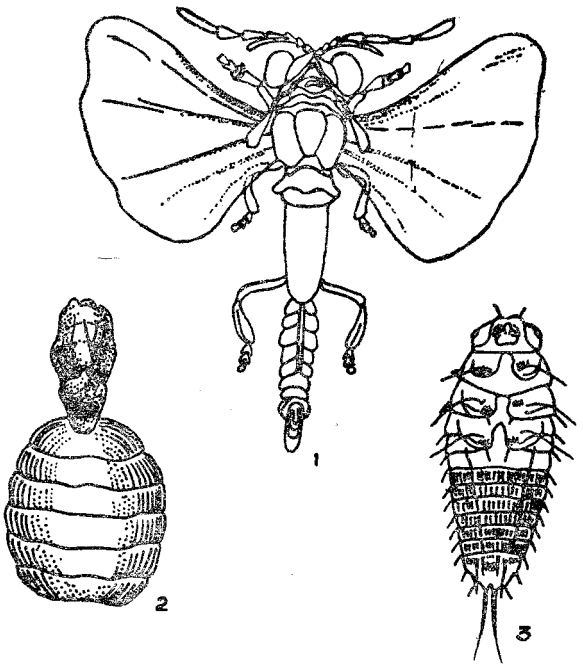


FIG. 56.—INDIAN STYLOPS (*Strepsiptera*).
1 Male of (*Trydactylophagus mysorensis*. Subr.)
2 Female of (*Pyrilloxena compactus*, Pier).
3 Triangulin larva of (1).

[*After T. V. Subramaniam, Mysore*]

20. *Strepsiptera* (*Stylops*).—This group was till recently considered to be a subdivision of the Coleoptera. It is a very small group of minute aberrant insects which are parasites on some bees, wasps, leaf-hopper bugs, etc. The males and females differ extraordinarily in structural characters (fig. 56). The former are winged, the first pair being reduced to stumps and the hind pair large and fan-like; the eyes are stalked and the antennæ leaf-like; the female is a worm-like bag without feet, eyes or feelers (fig. 56-2). The mouth parts are degenerate biting structures. The insects undergo a complete metamorphosis. These are popularly known as *Stylops* and the hosts parasitised by these insects are said to be *stylopised*. Very little is known of these insects in India and the little information we have of the few known ones is to be found in the papers by T. V. Subramaniam, the former Mysore Entomologist.

21. *Lepidoptera*.—In numerical strength this order stands next to the beetles and includes numerous forms of very great economic importance. The members of this order are specially characterized by the scaly covering of the body and wings and the characteristic structure of the feeding apparatus which is a long tube remaining curled up like a watch spring under the head when the insect does not feed; during the act of feeding the tube unwinds, reaches the food material and pumps up the liquid nutrition. One important feature in this group is, that while the adult insects possess the above described sucking mouth parts, in the young ones—which are known as *caterpillars*—the feeding apparatus is of the ordinary mandibulate type. All the Lepidoptera pass through a complete metamorphosis and from an economic point of view it is the caterpillar that is, in most cases, the really injurious stage of these insects. The order includes all moths and butterflies. The latter are generally day flying insects and include fewer groups of economic importance than the moths which are usually nocturnal in habits. Numerous families are included in this order. The more important of the families of economic importance in the subdivision of moths (*Heterocera*) are the family of stout moths (*Noctuidæ*) which includes the species of the numerous cutworms like the tobacco caterpillar and the paddy swarming caterpillar, the loopers and semi-loopers found on castor, tobacco, etc.; the leaf and borer caterpillars (*Pyralidæ*) which include the borers in paddy, sugarcane, etc.; the Hawk moths (*Sphingidæ*) adults of sphinx caterpillars found on gingelly, lablab, grape-vine, etc.; the hairy caterpillar moths (*Arctiidæ*) which are often serious pests on cumbu, cholam and groundnut; the tussock moths (*Lymantridæ*) found on castor, mango, gogu, etc.; the slug caterpillars (*Limacodidæ*) found on mango, castor, palms, etc.; the leopard moth (*Cossidæ*) found as borer on agathi; the two families of silkworms, viz., *Bombycidæ* including the mulberry silk-worm and *Saturnidæ* including the tassar and eri worms and the numerous families of small moths including leaf miners, fruit borers, etc.,

which are generally grouped under the designation *Microlepidoptera*. The subdivision of butterflies (*Rhopalocera*) as stated above does not include as many forms of economic importance as moths. The group known as swallow tailed butterflies (*Papilonidæ*) though including numerous species of very pretty forms does not contain any insects of economic importance excepting the species feeding on rutaceous plants like oranges, lemons, pomelos, *Murrayia*, etc. Under the forms known as skippers (*Hesperiidæ*) we have those on paddy, sugarcane, turmeric and coconut; the blue butterflies (*Lycænidæ*) include insects like the pomegranate fruit borer, the cow pea butterfly and the citrus leaf folder; under the white and yellow butterflies (*Pieridæ*) we have the agathi and cassia feeders and the last group (*Nymphalidæ*) includes some of the commenest butterflies of the plains, such as those found feeding on Calotropis, Cassia and Nerium; the horned paddy caterpillar, the castor butterfly and the famous protectively colored *Kallima* (fig. 39) are examples.

22. *Diptera*.—The forms included in the order Diptera are popularly known as flies and are easily distinguished from all other insects by the possession of only two wings—hence the name of the order. The hind pair of wings is reduced to two small pieces called the *Halteres* or balancers, and it is only the front pair, the mesothoracic pair, which functions as the organs of flight, though the halteres help the insect in properly balancing itself while flying. Though the mouth parts of Diptera are primarily of a suctorial nature, two or more modified types of such a mechanism are met with; the more important ones are the piercing type found in the case of mosquitoes and other blood-sucking flies and the sponging type of the house-fly and other non-blood sucking Diptera. All flies pass through a complete metamorphosis with a distinct pupal stage. In some forms the pupa has a distinct cocoon (*Cyclorrhapha*) as in that of the house-fly, in others the pupa has no special covering (*Orthorrhapha*). A few flies like blue bottles and horse flies are viviparous and give birth to active maggots instead of eggs. This order is divided into numerous families including some forms which are of great economic importance. The more important of such families are the gall-flies (*Cecidomyidæ*) represented in South India by the paddy gall-fly (*Pachydiplosis oryzæ*, W.) and the gingelly gall-fly (*Aspondylia sesami*, F.), the mosquitoes (*Culicidæ*) including some malarial (*Anopheles* spp.) and non-malarial (*Culex* spp.) forms, the moth and sand flies (*Psychodidæ*), the cattle and horse flies (*Tabanidæ* and *Hippoboscidæ*) attacking cattle and other domestic animals, the fruit flies (*Trypetidæ*) found especially on mangoes and cucurbitaceous fruits (*Chætodacus incisus*, W. and C. *ferrugineus*, F.), the stem and shoot boring flies (*Anthomyidæ* and *Agromyzidæ*) of some cereals and pulses (*Atherigona* spp.), the group of common flies (*Muscidæ*) including the common South Indian house-fly (*Musca*

nebulo), the scavenging flesh flies (*Sarcophagidæ*), the bot flies of cattle and horses (*Oestridæ*), the group of very useful flies (*Tachinidæ*) which are parasitic and act as natural enemies of numerous insect pests and the hover flies (*Syrphidæ*) some of which are predatory on plant lice. Among the other groups of the order are the crane flies (*Tipulidæ*), robber and soldier flies (*Asilidæ* and *Stratiomyidæ*) and the bee flies (*Bombylidæ*).

23. *Aphaniptera* (*Siphonaptera*).—This division of insects which includes the fleas was till recently included under the Diptera as a sub-group but it has now been given an independent status as a separate order. These are small insects (*fleas*) with the body laterally compressed and the hind legs well adapted for jumping. They have no wings and the mouth parts are adapted for piercing and sucking. The insects undergo a complete metamorphosis and the different stages can be found in the haunts of rats, dogs, etc., and in dusty and unclean corners of rooms in buildings. They have only simple eyes and the antennæ are small and concealed. These insects live as blood-sucking ectoparasites on higher animals like dogs, cat, rat, etc. Common examples of these are the rat (*Xenopsylla cheopis*), the cat (*Ctenocephalus felis*) and the human (*Pulex irritans*) fleas of which the rat flea is known to carry the germs of plague from rats to human beings.

24. *Hymenoptera.*—This is a distinctly differentiated and well-known order and has not undergone any marked changes from the fundamental old classification. All the forms included in this order have a complex arrangement of the mouth parts showing different grades of a combination of biting and suctorial parts. The winged forms possess two pairs of wings ; the structure of these is quite characteristic of the order in being medium sized, hyaline and possessing fewer veins unlike as in the dragon flies or other insects. The fore wings are larger than the hind ones and these latter are closely attached to the posterior margins of the front wings often by means of a row of small hooklets. All Hymenoptera pass through a complete metamorphosis. The possession of a stinging organ is common among the Hymenoptera and many females possess a conspicuous ovipositor which, in some cases, is longer than the whole body of the insect. In this group we not only come across numerous parasitic forms, many of which possess considerable economic importance as natural enemies of several insects which are pests, but we have also the useful honey bee and other forms which are beneficial as flower pollinators. Examples of maternal care of the offspring and social life are found in this order much more than in any others. The order includes all the insects falling under the main groups known as ants (*Formicidæ*), the numerous bees including the leaf cutter bees, carpenter bees, the honey bees and parasitic bees included in a big group (*Apoidea*) and a host of other subdivisions including numerous hymenoptera known popularly as wasps. This latter includes the saw flies (*Tenthredinidæ*), the hunting, digger and ground wasps (*Pompilidæ*,

Scoliidæ and *Sphegidæ*), the parasitic cuckoo wasps (*Chrysididæ*), the velvet ants (*Mutillidæ*) and the numerous parasitic wasps, some of them economically very important (*Ichneumonidæ, Braconidæ* and *Chalcidæ*). Excepting the saw-flies, of which there is only one injurious species known from South India, and a few ants and bees, most of the insects of this order are harmless to crops.

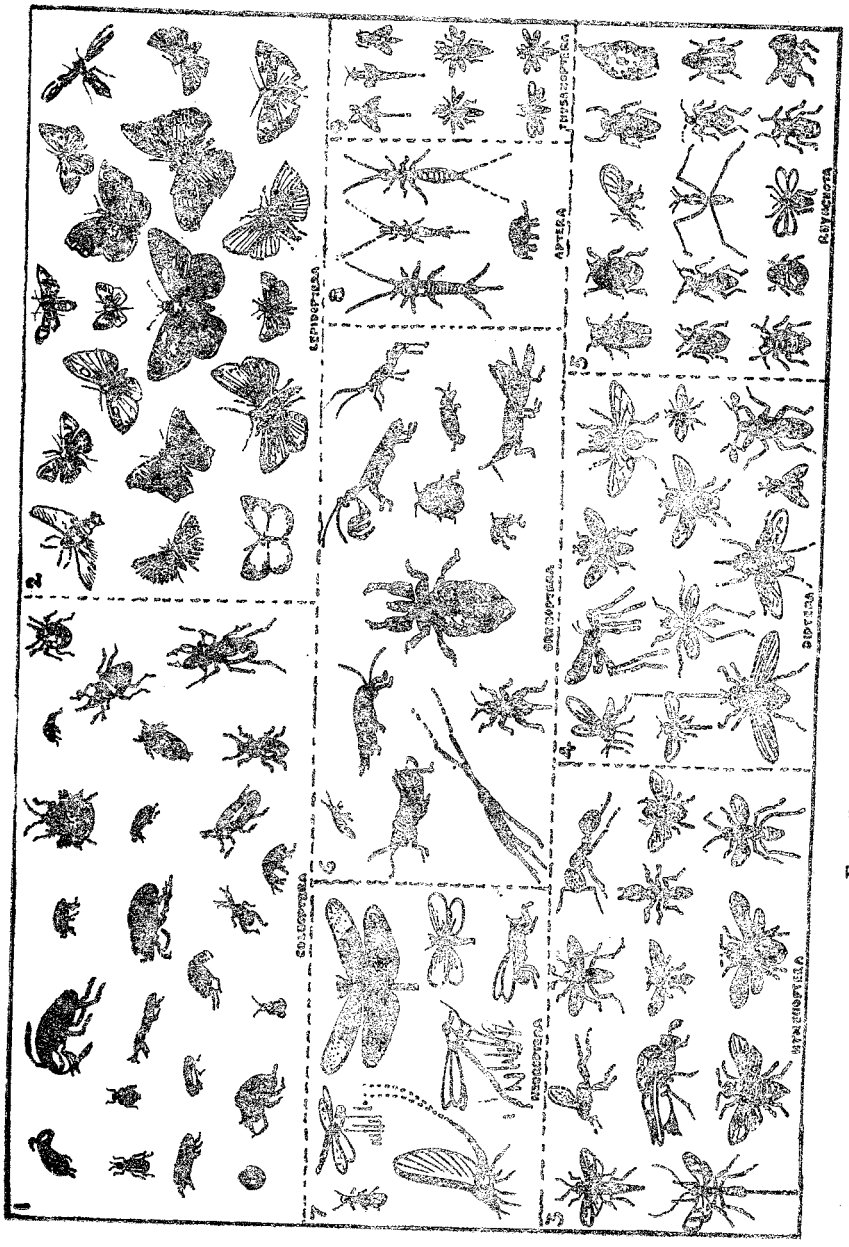
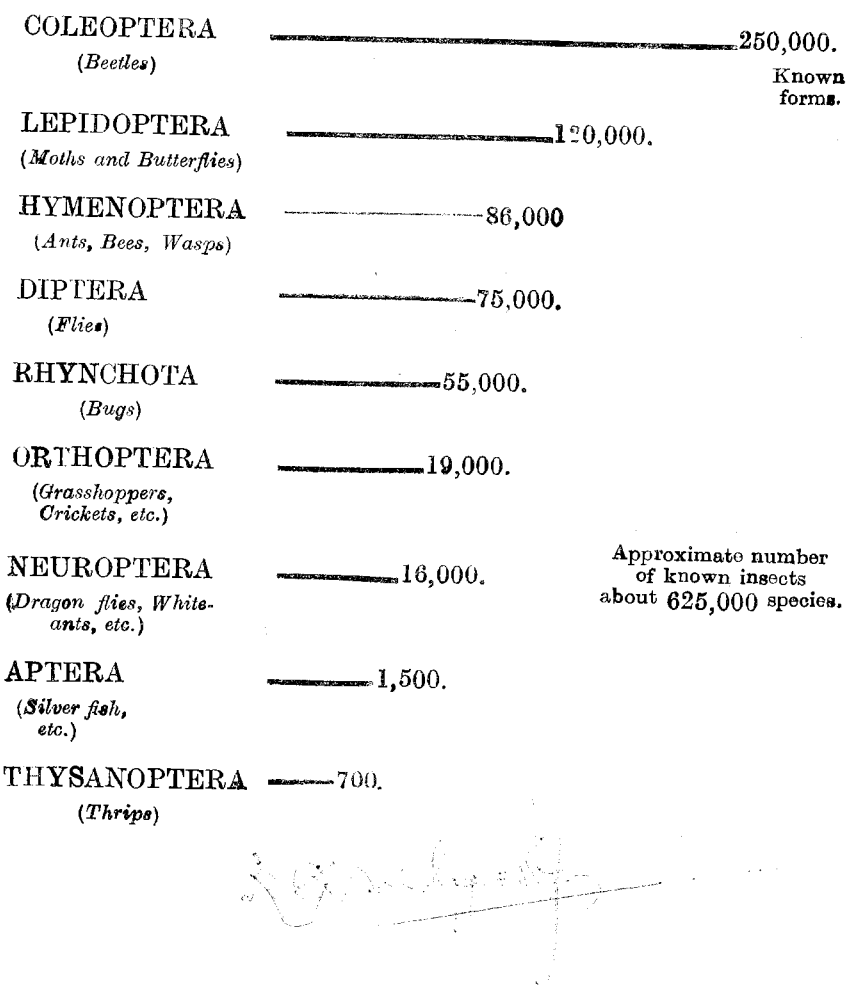


FIG. 57.—REPRESENTATIVES OF INSECT ORDERS.

DIAGRAM SHOWING THE COMPARATIVE SIZE AND APPROXIMATE KNOWN STRENGTH OF EACH OF THE IMPORTANT INSECT ORDERS.



PART II

ECONOMIC ENTOMOLOGY.

CHAPTER VII.

Economic Role of Insects.

Different aspects of Entomology—Economic Zoology—Insects and man—Popular classification of Insects—Good and bad insects, Insect-pests and factors governing their outbreaks.

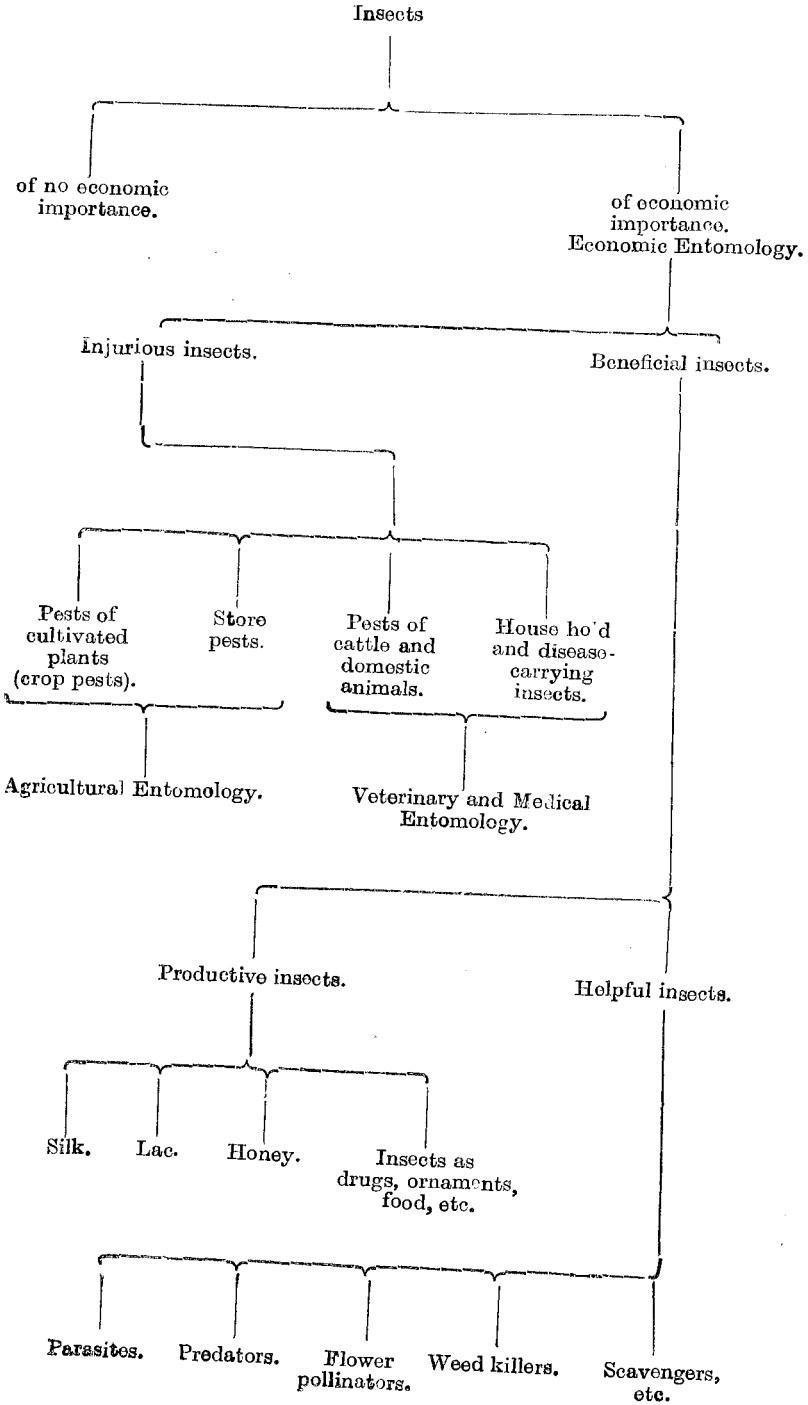
As stated before, insects, like all other animals, may be studied from different view points. The term Entomology, in its widest sense, includes a study of insects in all their various aspects and some of these latter go to form specialized branches of Entomological study, though they are all very closely related to each other. That aspect of the science, which is more or less comprehensive, includes the study of the general characters of all insects including their structural features, activities, life-histories, classification, distribution, affinities and all such factors from a scientific and biological standpoint—may be termed *General Entomology*. The matter in the last six chapters might have given the reader a very brief idea of this important and very wide field of insect study. Another aspect of Entomology is the special study of insects from the standpoint of their numerous relations and activities affecting the interests of man. This branch of Entomology which evidently deals with the role of insects in the economy of man is known as *Economic Entomology*. Just as Entomology is a special branch of Zoology, Economic Entomology forms a subdivision of the subject of Economic Zoology which is far more comprehensive, including as it does not only the study of insects but that of all living animals in their relations to man. Wilson, the late Chief of the United States of America, Biological Survey, has very beautifully summed up the importance of Economic Zoology and the value of the economic zoologist in his relations to human activities in the following words :—

"In its relation to public welfare economic zoology is of the most vital and far reaching importance. Animal life from its lowest organisms, among which lurk some of our deadliest foes as well as beneficient friends, to the highest vertebrates, touches and affects our lives and welfare in innumerable ways. It must be studied in all its phases as never before to guard against previously unsuspected or little known diseases of man and domestic animals as well as to develop the wealth and ever increasing variety of products from which we obtain food, medicines, clothing, dyes, ornaments and an endless number of useful articles. No man can be considered well informed who has not a considerable knowledge of economic zoology in its more direct relationship to human life, while to the scientific investigator the subject has the charm of endless variety and service to mankind."

The economic aspect of Entomology very intimately concerns the cultivator, the stock breeder or the householder, and the main object of this book is to deal with this important economic side of the subject with special reference to South Indian insects.

Insects and man.—It is well-known that from very early days when half civilized man gave up his nomadic and predatory habits and began to raise crops and tend cattle in settled localities the normal conditions of life in nature started undergoing changes in various ways ; animals, plants and man came into more frequent contact and conflict than before and the struggle for existence and supremacy among them has continued ever since. Speaking of the relations existing between man and animals, it might be safely said that no group of animals has so far approached insects in their intimate relations with man and his belongings either in diversity or in magnitude. It is common knowledge that insects affect human interests both for good and evil though their injurious proclivities are better known to us than the beneficial aspects of their activities. Nor can we conclude that all insects as a group have something or other to do with man since there are a good many forms which do not directly affect human interests either for good or evil.

Popular classification of insects.—From the above facts and based mainly on the economic aspect of the subject we can conveniently classify all insects into three convenient groups, *viz.*, Harmless, Injurious and Beneficial forms. For the present we can leave out of consideration the first group which, though including thousands of insects, is not at present found to affect the economy of man. It must, however, be noted that there are no hard and fast rules in nature which prevent any insect from changing its existing habits and thereby affecting human interests ; it is quite possible that altered conditions might now and then turn a harmless insect into an injurious form and *vice versa*. Coming to the other two groups which constitute the really economic forms, we can conveniently group them into special categories according to the nature of the good or evil the different forms are capable of producing in the economy of man. The following tabular arrangement will be found explanatory of this popular classification of insects :—


Insects
of no economic importance.
of economic importance. Economic Entomology.
Injurious insects.
Beneficial insects.
Pests of cultivated plants (crop pests).
Store pests.
Pests of cattle and domestic animals.
House ho'd and disease-carrying insects.
Agricultural Entomology.
Veterinary and Medical Entomology.
Productive insects.
Helpful insects.
Silk.
Lac.
Honey.
Insects as drugs, ornaments, food, etc.
Parasites.
Predators.
Flower pollinators.
Weed killers.
Scavengers, etc.

Beneficial and injurious insects.—Being familiar only with the injuries done by insects which are commoner and more evident, our farmers, often doubt whether there can be any good insects at all. Most of them do not have any proper ideas of the good services rendered by many insects. It is therefore desirable that every farmer should realize that among insects there are several forms which are beneficial to him and learn to recognize the good from the bad and not condemn them all alike! " The first step towards vanquishing an enemy " in the words of Curtis " is to ascertain correctly its habits, the next is to be certain of its appearance as not to mistake one party for another, and a third and no less important object is to be well acquainted with our friends and allies." From the table it may be clearly found that beneficial insects help man in different ways in the same manner as injurious ones cause him damage and loss. Though it has to be admitted that there are some insects which are beneficial to man in different ways, as far as we know, the number of injurious insects and the extent of damage caused by them are far greater than the gains caused by good insects. In this country though our farmers and householders are aware of the different forms of damage caused to crops and other things they have no clear ideas of the enormous losses periodically caused by insect pests of sorts, nor have we any accurate or reliable statistics of such periodical losses. To the average farmer it is only the occasional flights of locusts or plagues of caterpillars which appear to impress him as pests, while he is blind to the many other insects which silently but steadily levy a heavy toll on our belongings year after year. The following remarks of two well-known American entomologists might give us some idea of the possibilities of insect damage and consequent material loss to any country:—

" It costs the American farmer more to feed his insect foes than it does to educate his children." [1]

" The yearly losses from insect ravages to crops aggregate nearly twice as much as it costs to maintain our army and navy, more than twice the loss by fire, twice the capital invested in manufacturing agricultural implements and nearly three times the estimated value of the products of all the orchards and vineyards in the United States of America." [2]

Taking only one casual example in India, the rice weevil causing damage to rice and other stored products all over India and Burma —the approximate annual loss to India due to weevil damage has been computed to be over hundred million rupees.[3]

Insect pest outbreaks.—Any insect or for the matter of that any animal or plant which becomes a source of trouble or loss to us is generally considered a pest, and among insects such forms are numerous and are of different kinds as may be seen from the grouping in the above table. An insect generally assumes the role of a pest when it causes appreciable damage and loss to our crops

[1] Webster. [2] Slingerland.
[3] Noel Paton—" Pamphlet on Burma Rice "—1912.

or other belongings ; and when such losses are very serious and substantial the insect is marked as a major pest. When the damage is slight or not worth reckoning or only occasionally serious the insect responsible is then regarded as a minor or sporadic pest according to the degree and frequency of its appearance. It is well-known that due to the action and reaction of various forces in nature what is known as a "*Balance of life*" is generally maintained in nature. Under normal conditions in the living world, the lives of plants and animals are so wonderfully adjusted that the extraordinary increase or multiplication of any one species to the detriment of another is held in check. It is believed that the most important factors which play their part in keeping such a normal balance of life in nature are of food, climate and enemies.

Balance of Life in Nature.

A. *Chief factors maintaining the balance—*

(1) Food.
(2) Climate.
(3) Natural enemies and diseases.

B. *Chief factors upsetting the balance—*

(1) Growing of single crops in large areas.
(2) The destruction of forests.
(3) The destruction of insectivorous animals.
(4) The frequent transport of animals and plants from place to place.

Many forms of life, especially lower animals often die of starvation and if they happen to depend on particular plants for their food, the absence of this latter during certain seasons checks their growth and multiplication ; in the same manner extremes of climate also act as important checks to multiplication of various animals and plants. The presence of various carnivorous animals which depend for their food on other forms of life also contribute their own substantial share in checking the multiplication of various smaller organisms. To these carnivorous enemies may be added the various diseases and maladies due to fungoid or bacterial nature which levy their toll on organisms of various kinds. It is only when one or more of these important natural checking factors are prevented from playing their parts freely that the normal equilibrium in nature is upset and opportunities offer themselves for the abnormal increase in some forms, which become pests. One of the most potent causes which helps to upset this balance is the part played by human agency. For, as civilization advanced and man began to conquer and control nature in various ways, numerous changes have been brought about in the life conditions of almost all organisms in the world and especially has it been so among the lower forms like insects, etc., and such changes account for the occasional multiplication of certain forms of life which consequently

become pests. Some of the more important human influences which help to upset the even level of insects in nature are—the growing of single crops in extensive areas, the destruction of forests for various human needs, the indiscriminate destruction of insect enemies such as birds, reptiles, etc., and the frequent and thoughtless transport of various forms of undesirable plants and animals from one country to another. These causes which take place daily must, to a greater extent, account for the frequent appearance of pests in these days. When we briefly examine these important factors, we find (1) The growing of single crops in the same locality in extensive areas helps any insect feeding on such plants to increase and multiply ; for, unlike as in the old days when such insects had to search out their food plant in the jungles and in that attempt risk several enemies and climatic influences, in a modern cultivated field a cholam or cotton insect is able to get plenty of food in the same field and thereby escape the operation of the checks mentioned above, viz., food, enemies and climate. (2) The destruction of forest areas nowadays for various purposes, besides upsetting the physiographical and meteorological conditions of any area, has gradually driven several insects originally living on forest vegetation to transfer their activities to economic plants and thereby become pests. (3) The reckless destruction of animals like insectivorous birds, reptiles and mammals and the conscious or unconscious extermination of numerous insects feeding on insects (*Entomophagous*) * effectively interfere with the functions of many creatures which act as natural checks of several pests. (4) * The frequent transport of plants and animals from one country to another for man's needs without in the least realizing or foreseeing the disadvantages has often caused disastrous results in some cases. The introduction of the rabbit into Australia and the mungoose into the West Indies and the consequent realization of these two as blunders are classical examples in that direction.

The four factors noted above are, as far as we know, the most important agencies frequently upsetting the natural balance of life and helping various organisms to multiply or get destroyed abnormally and interfere with human interests. But in any case of pest outbreak it may be often very difficult to point out exactly which of these various factors is responsible for the outbreak ; for, in most cases, it may be due to one of these or a combination of one or more of these factors.

* For some details on these two subjects reference may be made to the author's papers of 1932 and 1933—Appendix E.

CHAPTER VIII.

Insect Pest Control.

Essentials in Pest Control.

Essentials in insect pest control—Different factors of control—Natural control —Artificial or applied methods of control.

Insect control stimuli and essentials in that direction.—The most important of the numerous stimuli which have contributed to the increased study of Economic Entomology in modern days have undoubtedly been the various attempts made by man at devising ways and means of controlling pests of various kinds. Having realized that the frequent outbreaks of insect pests are chiefly the results of his own conscious or unconscious activities through centuries, man has also been devising, from time to time, various methods for keeping under control pests of different kinds in most of the countries where scientific methods of agriculture have become pretty well established. For an effective and economic application of the different methods of control so far known, it is essential that one should possess correct ideas of the insect pest he has to deal with. It may be emphasized that a knowledge of the life history of an insect will be of very great help in adopting the measures suitable against particular pests; such a knowledge will help any one as to when, where or how to strike the pest at its weakest point. There are some insects which lay eggs in clusters of a hundred or more in well exposed places like hairy caterpillars on cholam, cotton, etc., whereas in the caterpillar or adult stage they are very active, dispersed and difficult to check. In such cases, the insect can be easily and effectively checked by promptly collecting these egg clusters and destroying them. There are others where the caterpillars or grubs feed gregariously—thousands of them on each leaf or branch like the tobacco worm *Prodenia* while there are still others having their vulnerable point in their pupal stage under the soil, or in their adult condition such as flying to lights, etc. When such cases are known it will be found very easy and effective to adopt the control measures in time. An ignorant farmer allows these vulnerable points of insects pass unchecked and finds himself in a fix when the creature has increased in numbers and assumed serious proportions! When once we get some idea of the ways of an insect pest, methods of control become a matter of common sense. It need hardly be stated that the best remedial measure is the one which is practicable, cheap and effective; otherwise the remedy will become more troublesome than the disease itself. Our farmer friends want ready-made medicines which will drive any kind of noxious insects like magic. But one who has known a little of the

ways and habits of various insects can easily understand the ignorance underlying such a request. Such general ideas regarding insects can be easily gained by a farmer by intelligent preliminary observations and records made through different seasons for a year or two, and then compiling a sort of pest calendar for the tract, similar to the ones on the Frontispiece and figs. 76 and 77. There is no doubt that as the farmer gets to know his important pests and their vagaries, he will himself be able to devise such control measures which might suit specific pests and special localities.

Insect control methods.—All the factors which play their part in the control of insect pests generally fall under two main categories, Natural and Artificial.

Natural control.—It is not an uncommon phenomenon to note that during certain seasons an insect pest unexpectedly disappears or increases in thousands without any interference from man; such sudden controls of insects are evidently due to natural courses. These factors chiefly include, (1) sudden climatic changes such as heavy rainfall, high temperature, etc., (2) natural barriers like streams, hill ranges, floods, etc., (3) changes in soil composition due to drainage, manures, etc., (4) natural enemies like parasites, predators, birds, etc., and their sudden increase or disappearance and (5) increase or decrease in the different kinds of fungoid, bacterial and other diseases which affect insects and their food plants. As has been explained in the last chapter some of these factors in nature are the ones which keep up the normal balance of life in nature.

Applied or Artificial control.—The different measures generally adopted by human agency in insect control may be grouped into, (1) Cultural, (2) Mechanical, (3) Chemical, (4) Biological and (5) Legislative. Some of the methods in these categories may be both preventive and curative: some of the cultural and legislative measures especially are preventives and help the cultivator in keeping away some pests.

Cultural methods.—As stated above many of these measures will be found to include also preventives or prophylactics checking the outbreaks of pests. The well-known saying that "Prevention is better than cure" is a very old maxim and is specially appropriate in many cases where we have to deal with diseases and pests of various kinds; but unfortunately the very sage advice contained in the pithy saying, is more honoured in its breach, than in its observance. It may be affirmed that, in the case of many insect pests, prophylactic measures will be found far more practicable and economical, than those adopted to actually fight a disease or pest when it has made its appearance, and when it often becomes too late to employ preventive measures, or, too difficult to resort to curative methods. In certain special cases, no other method other than preventives will be found practicable.

Some of these cultural methods constitute what may be termed as field and plant sanitation. This include (1) Keeping the fields clean by regular removal of all weeds is important, since many crop insects feed on some weeds when their cultivated food plant is not available. Examples of such insects are—the Paddy mealy bug, the Rice bug, the Army worm, the Sunnhemp moth, the Fruit moth, etc. (2) Pruning of dead branches, removal of loose bark, scraping of the unhealthy stems and patching up wounds with clay and tar in fruit and other trees of economic importance. These measures will kill some insects which lurk or hibernate in these situations in one of their many stages, and which would otherwise attack the healthy parts of the plants in due course. Examples are shoot, bark and stem-boring beetles, bark caterpillars, etc. The removal of the dead and splitting of crownless rotting palm trees and drying the stems will keep away the palm weevil and the rhinoceros beetle in coconut gardens. (3) The removal of all crop remains after harvest such as stubbles of cereals like paddy and cholam, old cotton, brinjal, sweet potato and cucurbitaceous plants. Failure to remove these, allows borers, etc., to breed unnoticed and appear on the crops during the following season. (4) Proper disposal of litter in cattle-sheds and stables. The trouble from domestic and cattle flies can be prevented by proper disposal of cattle yard and stable manure in which flies of all sorts breed, multiply and become not only a nuisance, but also play their part as disease-carriers in some cases. (5) The oiling of stagnant pools and ponds to prevent mosquito breeding is a similar measure. Under this heading may also be brought the periodical raking up of the manure heaps, to prevent multiplication of the rhinoceros beetle and other cockchafer larvæ which breed in them.

Other preventive measures.—(1) Treatment of cane setts before planting: Before planting sugarcane and grape-vine setts may be treated with copper sulphate, dilute crude oil emulsion or tar water to prevent white ant, mealy bugs and even borers.

(2) Other measures of a cultural nature also include some which are preventive and some curative in effect. These are (1) deep ploughing in generally—To destroy weeds, white grubs—in many cases attacking garden crops like chillies, groundnut, etc., pupæ of hairy and sphingid caterpillars often attacking crops like groundnut, greengram, sweet potato and gingelly, this method will be found very helpful. (2) Periodical cutting open and making up of field bunds for destroying grasshopper eggs in paddy areas like Malabar, Ganjam, etc., forms another preventive measure in such areas. (3) Flooding of fields when plenty of water is available will bring up the insects remaining underground like cutworms, white grubs, etc. (4) Crop rotation—It is, perhaps, not widely realized that, apart from its agricultural benefits, this method of growing crops in rotation on any area is also beneficial in checking the multiplication of some insect pests which would

otherwise continue breeding in the same area right through the year. (5) Digging out and destroying ants' nests in fields ; white-ants attack on wheat, groundnut and cane, and the occasional outbreaks of red-ants on brinjal and other garden plants can be prevented by this prophylactic measure. (6) Raking up and hoeing of the soil around melon plants and around mango and other fruit trees like guava, zizyphus, etc., which suffer from attacks of fruit flies will destroy the underground pupæ of these flies and prevent further breeding ; this may be done for plants suffering from flea beetle and leaf beetle attacks also—such as the Pollu flea beetle in pepper areas, the pumpkin and other leaf beetles and the beetle pests of grape vine. (7) Thorough drying before storage—The thorough drying and chaff-free storage of harvested crops like grains, pulses, oil-seeds, ginger, turmeric, nuts of different kinds, pepper, cardamoms, chillies, etc., will prevent the infestation and multiplication of many pests like weevils, moths, mites, etc., which are partial to such stored products. It has also to be remembered that there is no good of storing such clean and healthy seeds in pest-infested and unclean cellars and vessels. Small quantities of valuable seeds may also be preserved in jars with a layer of sand on the top surface ; this is found to prevent weevil breeding in many cases. It is only when it is found impossible or impracticable to adopt intelligent and prompt preventive measures that the necessity for adopting what may be called 'Direct' curative methods arise. These latter include a variety of measures, though the choice of the one suitable for a pest depends a good deal on such important factors as the nature of the pest and the practicability of the control method from the point of view of economy and Local conditions.

Mechanical and physical methods.—These include the various manual operations such as Handpicking, Netting, Bagging, Trapping by mechanical devices such as light traps, stickyboards, fly, moth, maggot traps, hopper dozers, etc., tarring, banding, jarring, heating, cooling, electrifying, trenching, flooding, creating barriers, etc. These are adopted according to the suitability of each pest concerned, and some of these mechanical devices are found to be eminently suitable against some important pests. Netting or bagging is very effective against insects like the rice bug, the paddy grasshopper, pumpkin beetles, etc. (fig. 58).

Light traps—(Fig 59).—Many insects including some well-known crop pests are attracted to lights ; the setting up of light traps at the very beginning of a season when a phototropic insect pest is likely to appear, will nip the pest in the bud and very greatly check its multiplication and reduce its menace as a serious pest. Such are the paddy stem borer, the groundnut surul, the hairy caterpillar moths, the cockchafer beetles, one or two of the sorghum and cane borers, the ragi white borer, the spotted jassid of paddy and many others. A study of the light trap catches in any area for a fairly

long period will give anyone an idea of the incidence of the phototropic insects and the time of the year when they usually appear. Even bonfires in field bunds at such seasons will serve the purpose.

FIG. 58.—HAND NET. [*From S.S.I.*]

Jarring is a common and easy method for leaf weevils on different plants and trees. Traps of different kinds are useful against leaf hoppers and flies. Trenching and barriers prevent the migration of swarming caterpillars. Covering ripening fruits to prevent insect attack—Pomegranate fruits of good quality and size are kept free from the borer butterfly by loose muslin or paper covers which prevent the butterfly from laying the eggs on the fruit. Batavian and allied varieties of oranges are often covered with cheap bamboo baskets in parts of the Northern Circars; this prevents the attacks of the fruit-sucking moth which is a bad pest in the area. Banding coconut trees with smooth sloping tin plates will prevent rats from going up the trees and causing damage to the nuts (fig. 406). A similar measure is the tarring of the stems of fruit and other trees to prevent white-ant infestation. The physical methods of heating, and cooling affect store insects of different kinds. Some of the above methods are preventive also as stated before.

Chemical or insecticidal methods.—These measures include the control of insects by the use of different kinds of chemicals in various ways. Most of the materials so used are known as *Insecticides* or insect-killing substances. Though the word insecticide literally connotes any substance which kills insects, it has nowadays gained a wider meaning also and has generally come to be applied not only to different drugs and chemical preparations which are actual insect killers but also to those substances which

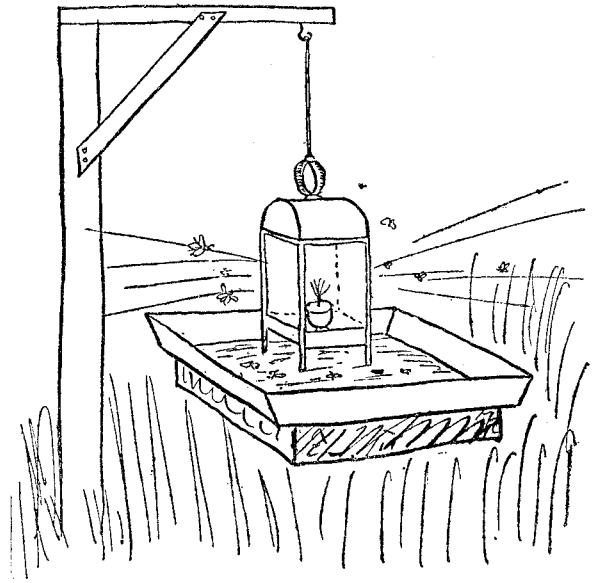


FIG. 59.—LIGHT TRAP.

FIG. 60.—SOME BITING INSECTS.

have a deterrent effect on pests, and it is in this latter comprehensive sense that the term is used in this book. According to the nature of their action, insecticides are conveniently grouped into two categories. Against biting insects (fig. 60) which bite and chew the food, the insecticides generally used are known as *Stomach insecticides*;

these when eaten with the plant tissue kill the insect by absorption through the alimentary canal. In the case of sucking insects which take only liquid nutrition (fig. 61) a stomach poison spread on the plant surface will not be able to reach the stomach since these insects get their food in the shape of sap from within the plant tissue ; hence the insecticides used for such insects are such which will kill them by coming into actual contact with the body surface ; these are called *Contact insecticides.* Besides these two main groups of insecticides there are others called *Fumigants* which kill insects by affecting the respiratory system in the form of a volatile poisonous gas. There is, in addition, a fourth group of insecticides used against insects called *Deterrents* which make the plant distasteful to the insect and which, by their peculiarities, repel the creature from the plant. The above grouping, though convenient, is more or less an arbitrary one ; for, in some cases, the same insecticide may function both as a stomach and contact poison or as a contact poison and a fumigant. It is well-known that, in many rural areas, farmers are in the habit of employing different kinds of sundry drugs and decoctions against different insect pests ; though a few of these rule-of-thumb operations possess

FIG. 61.—SOME SUCKING INSECTS.

the nucleus of some of our modern effective measures, the bulk of them have been found to be quite ineffective and to consist of quack nostrums suggested by rural charlatans and mountebanks ; the use of insecticides on rational lines began only from the middle of the last century.

Stomach insecticides.—Most of the insecticides of this class in use at present are composed of arsenic, combined with some other substance to render it insoluable in water. These are applied as food poisons ; very often they are protective, since the application may be made even before the insects to be destroyed are actually present. The essential properties of a stomach poison are that it should be sufficiently toxic against insects, must not harm the plant, and should be insoluble in water. These can be used against biting insects like caterpillars, beetles, grasshoppers, etc. The more important of these stomach insecticides known are the following :—

Paris green.—This is a bright green powder the main ingredients of which are copper acetate and copper arsenite (*aceto-arsenite of copper*). As this substance when used alone has a tendency to burn the foliage in some cases, it is advisable to mix an equal or double the quantity of quicklime to remove or lessen the danger of scalding ; an excess of lime will not be harmful. It can be used both as a spray mixture and a dry powder for dusting. In the former case the usual proportion is 8 to 10 oz. of paris green to 100 gallons of water. The powder should first be made into a thin paste in a small quantity of water and 2 pounds of quicklime added ; then the necessary water may be added and the mixture thoroughly agitated before use. For use as powder the substance may be mixed with four or five times its volume of lime and dusted on the plants, either through thin cloth bags or by means of a dusting machine. This insecticide is generally sold by chemists at a cost of about one rupee per pound. Due to its injury to foliage in some cases, it is not as popular as lead arsenate or calcium arsenate.

Lead arsenate.—This is a white substance produced from the ingredients lead acetate and soda acetate. It is insoluble in water, harmless to plants, and easily applied either in the liquid form or as a powder. With regard to the solubility and the corresponding danger of burning the foliage, aresenate of lead is superior to other known arsenites such as paris green, calcium arsenate, etc. It is procurable either in the form of a paste or as a dry powder at the same cost as paris green. The usual proportions are, in the paste form 1 oz. to 4 gallons of water, and in the powder form 2/3 of an ounce to the same quantity of water. There is no risk even when a slightly stronger dose is used. Its efficacy in spraying may be increased by adding some molasses and lime to the mixture, the usual proportion being 3 pounds of lime and 6 pounds of molasses for every pound of arsenate used. As a dry powder it is generally mixed in the proportion of 1 pound of the powder to 10 or 15 pounds of some neutral powder like wood ashes, powdered lime or road dust and dusted as in the case of paris green. Though slightly costlier its safety as regards foliage burning and its adhesive quality make lead arsenate a safe, effective and popular stomach poison and its use all over the world has met with considerable success.

Calcium arsenate.—This insecticide is more or less similar to lead arsenate, the chief difference being the replacement of the heavy lead by the lighter metallic component. It is also sold as a white powder and is cheaper than lead arsenate. It can be used in the same way as lead arsenate either in the form of a liquid spray or as a dry dust. From a comparison of the properties and effects of the two insecticides it may be stated that while lead arsenate forms an excellent spray material as a liquid, calcium arsenate is of greater value when used as dust.

All these stomach insecticides can be used as insect baits also in various ways to trap cutworms, underground insects, grasshoppers, ants, locusts, etc. The usual method is to mix very small quantities of these arsenicals with various attractive and sweetened food materials like flour, bran, potatoes, bananas, etc., and leave small bits of the poisoned bait in the haunts of the various insect pests; this poisons and kills them in numbers. Among other stomach poisons are zinc arsenate and lead chromate which are not so very popular as lead arsenate and calcium arsenate. *In using these arsenical stomach poisons it must be remembered that they are all very poisonous, and, as such, all proper precautions should be taken to see that there is no danger to human beings, cattle and other domestic animals.* The materials should be kept properly labelled as poison and should be handled only by responsible persons. Usually the sprayed or dusted poison completely disappears from the plant in about three or four weeks. It is preferable, however, to use other insecticides against vegetables, fruits, etc., which may have to be used very soon, or if arsenites are used it is advisable to use such vegetables after washing them well. Non-arsenical materials like sodium fluoride, fluocilicates of calcium, sodium and barium and vegetable drugs like *Hellebore* and *Derris* are nowadays used on vegetables against biting insects.

Contact insecticides.—Contact insecticides are of various kinds; all of them contain as effective ingredients either some sticky or irritant substance, and in some cases, both these. These are generally sprayed in the liquid form on the infested plants with the insects *in situ* and usually used against sucking forms like plant lice, scales, mealy bugs, mealy wings, leaf hoppers, etc.; they may also be used against very delicate and small leaf eating larvæ with some success. The following are some of the well-known contact insecticides in use :—

Soap solution.—A solution of any ordinary bar soap is a simple and cheap contact poison against soft-bodied insects like plant lice, mealy wings and delicate larvæ. A potash soap remains in solution better and is more readily sprayed and effective against insects than soaps made with caustic soda. One pound of soap dissolved in 5 or 6 gallons of water will be found effective against plant lice or other soft insects.

Fish oil rosin soap.—This is a ready-made insecticide sold in some of the oil and soap factories. It is available as a dark-brown

semi-solid stuff which can be readily mixed with cold water and sprayed on the plants to check all kinds of sucking insects—especially plant lice, scales, mango hopper, etc. The usual dose is 1 pound of the soap to 8 gallons of water; the strength of the mixture may be made strong or weak according as the insect to be treated has a hard or soft covering. In the case of hard scales the dose may be strengthened in the proportion of 1 pound of the soap to 4 or 5 gallons of water. In some cases, a second or third spraying may be found necessary to tackle recently hatched nymphs, or those which escape the earlier applications.

Kerosene emulsion.—This is one of the oldest known of insecticidal preparations and is generally prepared on the spot when wanted; the usual recipe is as below: Finely divide half a pound of soap and dissolve it in a gallon of water by boiling; remove the fire and add 2 gallons of kerosene. The whole mixture should be violently agitated until the oil is completely emulsified; this may be done by being pumped upon itself by a force pump. If well prepared, this emulsion will keep long as the stock solution and can be diluted with 15–20 times of water before spraying; it may be made stronger or weaker according to the kind of insects and nature of the plant. With hard water more soap should be used. To make the spray stick to the surface an ounce or two of glue may be added to the mixture before spraying.

Crude-oil emulsion.—This is another contact insecticide made on the same principles as kerosene emulsion but with a heavy soap made from fish-oil and crude heavy petroleum. Such a heavy preparation will have a more permanent and thorough insecticidal effect in tropical climates where evaporation is rapid. In purchasing this insecticide care should be taken to discard drums containing old and bad stuff wherein the free black oil is found floating on the surface of the contents. Crude-oil emulsion is useful against all kinds of sucking insects; the usual spray dose is 1 pound of the emulsion mixed with 8 or 10 gallons of water. It can also be used in dilute solutions to wash cattle and domestic animals to remove vermin such as ticks, lice, fleas, etc. Sugarcane setts dipped in a solution of this substance before planting keep off to some extent white-ant attacks, and underground insects of sorts are also controlled in fields by mixing some of this stuff with irrigation water. In the use of kerosene and other oil washes on trees, the liquid should be applied only as a fine mist and not allowed to run down the trunk and collect around the tree below; this latter will exercise a harmful influence on the tree by the accumulation of the insecticide.

Sulphur.—Sulphur and its compounds form some of the most important of contact insecticides. As a fine dust it checks mites on various plants. It is also sometimes mixed with lime, arsenate of lead, tobacco, etc., for use as combined insecticide and fungicide.

Lime sulphur is an efficient fungicide and a good contact insecticide as well.

Tobacco (*Nicotine*).—Tobacco and its products are some of the best known of insecticides at present available; there are various standard preparations of tobacco (*nicotine*) sold under different names. For all practical purposes tobacco decoction can be easily prepared when wanted as below:—Boil a pound of tobacco (the refuse stems and powder will do very well) in a gallon of water for half an hour or by steeping it in cold water for a day. In the tobacco decoction, dissolve 4 ounces of any ordinary bar soap. This soap and tobacco mixture when cool is to be diluted with six or seven times of water and sprayed on the infested plants. This will be found useful against plant lice and mealy bugs affecting all plants, especially on those where the foliage is used and where one would like to avoid the smell of kerosene or fish-oil. This is the case when the tobacco plant itself is attacked by plant lice as is very often the case. Soap when used with tobacco has been found not only as a good spreader but also to appreciably increase the efficacy of the nicotine agent. Tobacco decoction has been very much in use recently against plant lice on tobacco in different parts of the province. As an easily available stuff and an effective preparation against most sucking insects tobacco has a very promising future as an insecticide. Dry side-dressing to prevent insect attacking young and low-growing plants, and tobacco smoke will act as a fumigant against very small and delicate insects.

Among other contact poisons known are soaps of sorts, rosin soda wash, extracts of Quassia, pyrethrum, derris and other vegetable drugs and some of tar by-products like phenyl, carbolinuem, sanitary fluid, etc. These may be used in various ways and for specific purposes as killing or deterring agents. Recently a decoction prepared from the seeds of the garden plant *Thevetia neriifolia* has been found effective against both biting and sucking insects in Coimbatore.

The recent discovery of the two potent insecticides—D.D.T.—*Dichloro-diphenyl-trichloræthane* and B.H.C.—*Benzene hexachloride*—during the last war has been one of the outstanding features in the progress of Economic Entomology. Both of them are essentially contact poisons, causing paralysis and the eventual mortality among insects. They also act as stomach poisons when taken in. The chemicals were primarily evolved for the control of disease-carrying insects like mosquitoes, flies, etc., but are now being exploited and rapidly perfected for use against insect pests attacking field crops and stored products. A number of commercial preparations of these substances have been put in the market, both in the dust and wettable forms. In South India, preliminary trials have indicated the remarkable potentialities of the two insecticides and it is hoped that further work will be of immense benefit towards the control of crop pests.

Fumigants.—Fumigation is the process of subjecting insects or insect-infested materials to the toxic fumes of a volatile chemical. This is a method which can be adopted only for treatment within any air-tight enclosed space like a room, a tight closing box or a stoppered glass jar. The essential properties of any fumigating insecticide are its sufficiently poisonous effect on the insect treated, its harmlessness when applied to plants, its ready volatility, its good powers of diffusion, and its cheapness. Fumigation is commonly adopted against pests of stored grains, pulses, seeds, etc., such as rice and pulse weevils, granary moths, meal-worms, etc.; it is also done to free furniture, rooms, etc., from insect vermin of different kinds such as fleas, mosquitos, bugs, etc. In some fruit-growing countries like South Africa, California, etc., insect-infested fruit trees are also fumigated. Nowadays nursery stocks of fruit trees are also fumigated to keep them free from pests. What is called soil fumigation is commonly adopted against various pests including insects like white-ants, wire worms and other underground pests like rats, etc. The following are the chief fumigants in general use: *Carbon bisulphide.*—This is a clear watery liquid which when exposed, rapidly evaporates and gives out an evil smelling vapour which is heavier than air. Though comparatively harmless to food-stuffs and fabric, it is poisonous, highly inflammable, and liable to explode. In view of these properties the substance has to be very carefully stored and handled only by experienced persons. It is commonly used to free stored agricultural products and other material which become insect-infested. The process of fumigation is usually done by keeping the insect-infested material with a measured quantity of the insecticide in a closed room or box for a definite period. The usual method is first, to ascertain the cubical area of the room or vessel, and then place the infested material inside the same; measure out the proper dose of carbon bisulphide into a shallow tray or pan and place it inside the chamber by the side of the material and close the room or vessel air-tight. The usual dose is one ounce of the fluid for every 15 cubic feet of space enclosed. After 24 hours, which is the usual period for the process, the chamber should be opened and the fumigated material properly aired, and then stored in insect-proof vessels. If the dose and the period prescribed are carefully adhered to, the material fumigated will be free from insects and will not suffer in any way; if they are stored grains or seeds, their food or germinating properties will not be affected. Fumigation destroys all insects from infested material, but does not, however, guarantee any future immunity from pests, unless properly stored in insect-proof vessels after the process. Because of its inflammable properties proper precautions should be exercised in using this fumigant; as mentioned before, the liquid should not be exposed to sunlight, and no naked lights or fire should be brought near it or close to the fumigation chamber. Besides its general use in the fumigation of stored products, seeds, etc., it is sometimes used as a soil fumigant against underground pests such as root lice, ants, crickets, rats, etc., and also as fumigant in controlling borers in tree trunks. This is the insecticide generally used by the Agricultural department

at present for purposes of fumigating farm seeds, etc. *Hydrocyanic acid.*—Fumigation with this substance was first employed in California against scale pests on orange trees. The gas is produced by the action of sulphuric acid on potassium or sodium cyanide. This gas is one of the most poisonous substances known and there is liability of considerable risk and danger if fumigation with this substance is not done carefully and by well-trained persons, with all the necessary precautions. It is considered too early to suggest this method to laymen in India. Cyanide fumigation is now done in most quarantine stations and ports of entry to destroy foreign pests entering the country with living plants, cuttings, seedlings, orchids, bulbs, etc. Nowadays considerable improvements have also been effected in the methods of cyanide fumigation. The latest is the replacement of the liquid gas by cyanide dust fumigation. *Cyanogas—Calcium cyanide.*—This substance is one of the dry cyanide powders which has come into some prominence as a fumigant. The use of this substance avoids some of the dangers caused in producing hydrocyanic acid from potassium or sodium cyanide. It is manufactured and sold in two or three grades as granules, dust, etc. This fumigant has been found to be effective against various bugs on plants, underground insects, rats, etc. For insects feeding on plants, the latter are enclosed by bags or tents and the dust pumped by means of a handy pump when the gas evolves; the insects are stupefied and drop dead. For underground creatures the powder is pumped into holes in the soil by convenient machines.

Among other fumigants in general use are napthalene, tobacco dust, sulphur, paradichlorobenzene, ethylacetate, carbon tetrachloride, chloropicrin, etc., which may be used for specific purposes; sulphur is found useful against mites on cholam, cotton, etc., and for mildew on mango.

Repellants.—These are substances which generally secure protection for plants against insect attack by their repellant properties towards some insects. The use of deterrents as such is not generally practised since a killing insecticide can itself be used if the cost is more or less the same. Among such repellants, Bordeaux mixture is well-known. It is primarily a fungicide, but it has been found very useful in repelling attacks of flea, beetles and leaf hoppers. Similar to repellants, there are some chemicals used which attract some insects which are therefore known as *Chemotropic* (*see* p. 53).

In addition to the common insecticides generally used, various special preparations are known which may be found useful against different kinds of insects, such as roachicides, anticides, culicides, larvicides, etc. (*See* Appendix C.)

Nowadays combined sprays effective against both insect and fungi which would considerably effect saving in labour and cost have also been adopted. Some well-known combination sprays are Paris green and Bordeaux mixture, Bordeaux mixture and Lead arsenate, Nicotine and Bordeaux mixture and Lime sulphur and Lead arsenate; an example of an undesirable combination is lead arsenate with oil emulsions.

CHAPTER IX.

Insect Pest Control—Appliances.

The choice and application of insecticides—Appliances for use of insecticides—Biological methods of control—Legislative measures.

The choice and application of insecticides.—With regard to the choice of insecticides to suit different pests and conditions, various factors have to be considered. In the words of Wardle—

> "The ideal insecticide should possess certain desiderata. It should be cheap, simple and effective; It should mix well and adhere well; it should be a good wetter and a good, spreader. It may be added that its ingredients should be easily procurable and transportable; it should keep well under varied conditions of climate; should not be liable to spontaneous combustion or explosion or chemical disintegration; should be toxic to a wide range of insects, and comparatively harmless to higher animals and plants; should be applicable at all times of the year and under all conditions of weather. Finally, an almost unapproachable ideal, it should be equally effective as a stomach poison or as a contact poison, No known insecticidal substance, needless to add, comes any where near this ideal, nor is it likely that such a perfect insecticide will ever be discovered."

But it will be advisable to keep in view most of the important factors stated above in the selection of a suitable insecticide. Before concluding this brief account of insecticides, a few general remarks may be added with regard to the form in which the various insecticidal preparations are usually applied to insect-infested plants, as this will help to understand clearly the subsequent references to some of the various insecticides in use. The following are some of the common methods :—

(*a*) The wet method or *Spraying* ; in this case, the substance is mixed with water in certain proportions and applied to the plants as a fine liquid spray,

(*b*) in some cases, the insecticide is used as a fine powder and applied to the plants ; this is the dry method and known as *Dusting*,

(*c*) when gas-evolving insecticides are used, the procedure is known as *Fumigation*, and

(*d*) occasionally some of the insecticides are mixed with food materials and placed in the haunts of insects as baits, this method is known as *Trapping* or *Baiting*.

All these methods of using insecticides are guided by different factors, especially the nature and habits of the insect, the local conditions and cost of materials and labour. In the case of the first three methods, spraying, dusting and fumigation, to produce the best effect, suitable apparatus may be found necessary to be effective and economical ; the following notes are added on the subject :—

Appliances—Sprayers.—The application of the various insecticides referred to in the previous chapter to be effective and economical should be made by means of proper contrivances or

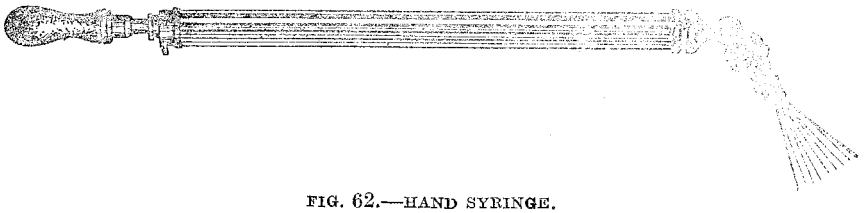


FIG. 62.—HAND SYRINGE.

[*From S.S.I.*]

FIG. 63.—A BUCKET SPRAYER.

[*From S.S.I.*]

machinery which will throw the insecticide as a fine liquid spray or a thin film of dry dust. Such a mechanism used for liquid insecticides is known as a spraying machine while these used for dry powders are known as dusters, blowers or powder guns. The essential qualities of a good spraying machine are its lightness, its easily workable and repairable parts, its efficiency, its strength and its durability. Various kinds of spray pumps are now available according to the needs of the agriculturists; but the selection of sprayers depends upon the quantity of spray material required for one application. For small gardens and domestic use, an ordinary simple hand syringe or atomizer (fig. 62) or a bucket pump (fig. 63) may be found suitable; for average sized areas like a fairly big vegetable or fruit garden a knapsack pump (fig. 64) might serve the purposes and for large areas barrel or tank sprayers on wheels (fig. 65) may be utilized with advantage. For operating extensive areas large outfits worked by steam line power and fitted with elaborate accessories for thorough and effective work are now in use in some of the Western countries. The most important parts of a spraying machine demanding special attention are the reservoir containing the spray liquid, the pump

FIG. 64.—KNAPSACK SPRAYER IN USE.

[*From S.S.I.*]

which propels the same and the nozzle or the metallic part containing the exit hole through which the liquid comes out as a spray. Considerable improvements have nowadays been effected with regard to spraying machinery ; the most important of these is the replacement of the old mechanical pumps by what are known as compressed air, auto, or pressure sprayers (fig. 66) ; in these latter air is pumped into the reservoir containing the spray mixture and this compressed air is utilized to expel the liquid without any manual pumping. The advantage gained by the use of these pressure sprayers is, that both the hands of the operator are free to direct the nozzle and there is no need for pumping, which saves a good deal of manual labour. The size of the reservoir or tank, the length, size and quality of hose, piping or rod connexion and the kind of nozzle or nozzles for spraying different kinds of infested plants, all depend upon the nature of the work to be done. Whatever the machine selected, whichever the insecticide used and however big or small the area treated, thoroughness and efficiency should be the main things to be aimed at. For this purpose it is necessary to select a machine suitable for one's purpose and keep it in good working condition when not in use. Before it is put back after use, the parts of the pump which come into contact with the spray mixture should be thoroughly washed and cleaned with cold water and the

metal parts of the pump, nozzle, etc., properly cleaned and greased. It is perhaps needless to add that spraying should not be done during rainy weather.

FIG. 65.—BARREL SPRAYER IN USE.

[*From S.S.I.*]

FIG. 66.—KNAPSACK PRESSURE PUMP.

[*From S.S.I.*]

Dusters.—For the use of insecticides as dry powders we have available on the market various kinds of dusters to suit different needs and tastes. This method is, in many cases, found far more economic than spraying and will be found particularly advantageous in places where water is not easily available. The simplest method of using dry insecticide powders is to put them

FIG. 67.—INSECTICIDE DUSTING.

[*From S.S.I.*]

in cloth bags and shake the bag over the plants to be protected (fig. 67). But to make the operation more effective and economic, the dust should be applied in such a way that it falls on the plants and covers the plant surface uniformly and without waste. This can only be done by a mechanism which will regulate the operation. Similar to spraying machines there are various kinds of dusting machines suited to different needs. These dusting outfits range from small hand shakers, powder bellows and fan blowers to big power dusters fitted on wheeled trucks and even aeroplane dusters for operating over extensive areas of field crops; and as in the selection of sprayers, the selection of a dusting outfit depends a good deal on the nature of requirements in each case. It may be also added that dusting will be found advantageous when done during the cool morning hours when the parts of the plant often contain dew drops which will help to retain the dusted powder on the plant surface; dusting will not be found economic or effective during the prevalence of strong winds.

Fumigation.—The application of insecticides referred to above as 'fumigants' is generally carried out as mentioned before in specially fitted gas-tight chambers or boxes; in the case of small quantities of farm seeds which may have to be treated frequently with carbon bisulphide, a special box called the fumigation box (fig. 68) may be maintained. This is a metal-lined box with a groove or gutter running along the upper edges containing water; into this groove the lid of the box fits in tight by means of a metal flange and thereby makes the box gas-tight.

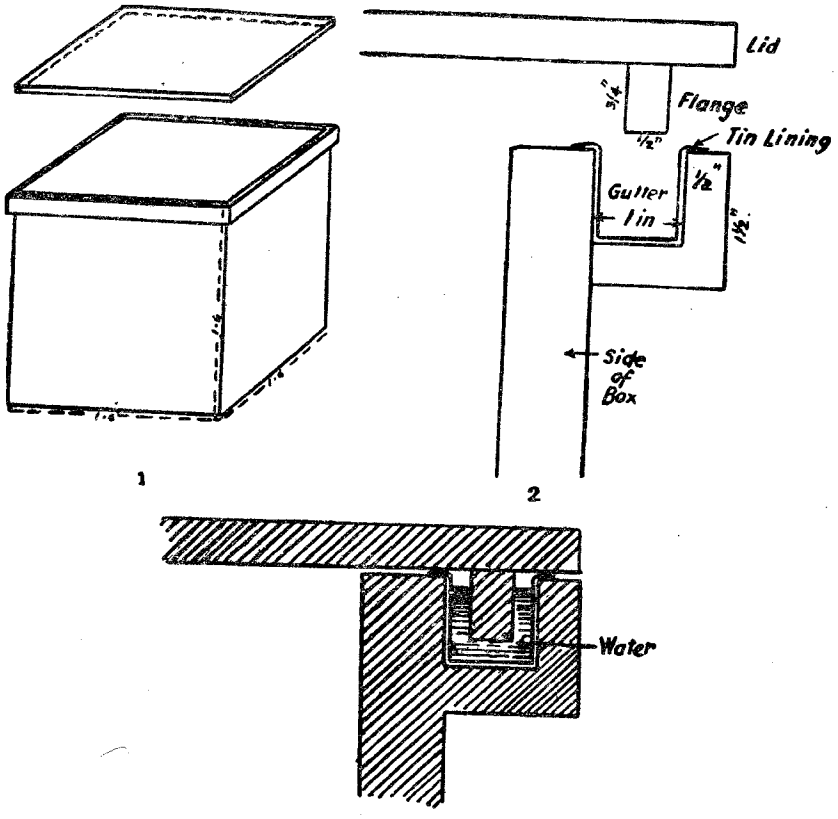


FIG. 68.—A. FUMIGATION BOX AND PARTS.

1. The fumigation box. 2 & 3. Parts of box and lid.

[*After* **Lefroy**]

Biological methods of pest control.—These methods of pest control consist in the utilization by man of the numerous natural enemies of pests—like predators, parasites, diseases, etc., to control or check various pests. These natural enemies chiefly include insectivorous birds, reptiles, frogs, etc., among higher animals, and creatures like spiders, centipedes, crabs, etc., and some insects also among lower animals. It is often noted that several insects which are parasites or predators on other insects (entomophagous insects) play a very important and substantial role in checking insect pests of various kinds. It is important, however, to note that, among these entomophagous insects, only such forms are of economic importance which depend for their food on particular species or groups of insects which are in any way harmful to man and not others which feed indiscriminately on various forms. A knowledge, therefore, of such insects and their life habits is quite essential before any biological methods of pest control are attempted. Prominent among these friendly

insects are the great bulk of the group of beetles called "lady-birds" (*Coccinellidae*), many "hover flies" (*Syrphidae*), the numerous lace-wing flies (*Chrysopidae*), the "bristle flies" (*Tachinidae*) and the hordes of parasitic hymenoptera. All these natural enemies are either predatory or parasitic in habits. Those of the former kind hunt their insect prey and feed on them like wild beasts while the parasites, instead of killing their hosts immediately, make use of them as food for their offspring by depositing eggs on or into their bodies; these eggs hatch and the larvæ grow at the expense of the body contents of the host which is gradually killed.

Predators.—The lady-bird beetles include the most important of the predatory insects of economic importance. These are well known to wipe away from insect-infested plants whole colonies of plant lice, scale insects, mealy bugs, white flies, etc., which are often found to be serious pests in most countries; and in countries like California, Australia and South Africa, etc., different species of these insects are regularly being made use of to fight scale and mealy bug pests of fruit trees. There are a good many species of these beetles in India but very little is really known of them, especially regarding their food habits. For example, the writer has recently found a new species of these beetles *Scymnus coccivora* (fig. 49), which has been noted to be an extremely effective natural enemy of the destructive nim scale (*Pulvinaria maxima*) in and around Coimbatore. Similar to the lady-birds, the larvæ of different kinds of lace-wing flies (*Chrysopids*) are also predatory enemies of plant lice, mealy bugs, etc., but they do not appear to be so very effective as the lady-birds for use on an economic scale. The larvæ of some flies destroying plant lice and eggs of mealy bugs are also known as friendly insects. Among other predatory insects useful to man, mention may be made of the caterpillar of a moth, *Eublemma scitula*, K. (fig. 70)—which is very commonly found all over India exercising an efficient control over some important species of scale insects; and another is a caterpillar, *Spalgius epius*—which feeds ravenously on destructive mealy bugs of sorts. Besides these, there are found stray cases of predatory beetles insect-sucking bugs, and robber flies, hunting wasps, etc., which occasionally help the farmer.

Parasites.—In the opinion of many experienced entomologists, the work of these insects is a very remarkable but little known phenomenon; outbreaks of pests are often suddenly stopped as if by magic by these useful forms. The insect groups of the greatest importance in this work are the tachinid flies and the parasitic hymenoptera (fig. 45). The former confine their attacks mainly to caterpillars of various moths and butterflies, many of which are among some of the worst crop pests, as for example—the swarming caterpillar of paddy and the caterpillar pests of grasses, tobacco, castor, sunnhemp, groundnut, cholam, etc. But our knowledge of these flies and their bionomics in India is extremely limited. As

far as the writer knows, one fly *Sturmia bimaculata* [fig. 45 (3)] appears to be one of the commonest in South India and known to parasitise some of the more important lepidopterous larvæ :* With regard to the work of parasitic hymenoptera one cannot help repeating what the late Dr. Sharp said : " The division parasitic hymenoptera," says he, "is one of the most neglected of the great groups of insects though it is perhaps of greater economic importance to mankind than any other." This large conspectus of parasites includes thousands of species exhibiting remarkable variations in structure and habits, and a thorough study of the bionomics of even a few of these interesting insects will not only help the economic entomologist who may wish to utilize them for pest control, but will be found to be of absorbing and fascinating interest even to the pure biologist. India abounds in numerous parasitic wasps carrying on their remarkable work of pest control often unknown and unnoticed by man, but unfortunately our knowledge of their life activities is very meagre. Examples of well-known parasites which are efficient checks on some South Indian insect pests are the braconid and chalcid wasps on the various borers of cane, millets, etc., the small braconid on the castor semilooper *Microplitis* (fig. 69) and numerous species of the genus *Apanteles* (Braconid) on various well-known caterpillar pests of different crops. Coming to the different methods in which such natural enemies may be utilized against insect pests to the best advantage, some of them are simple and quite practicable in most cases. Where plants are badly infested with pests say caterpillars, or different kinds of grubs, instead of the infested parts being removed and burnt or buried, as is at present done in most cases, they may be kept enclosed in cages with gauze netting to allow the natural enemies alone to emerge in due course; the mesh of the gauze should be of such dimensions that it will allow only the natural enemy to fly out and not the adult of the pest which, in most cases may be a moth or butterfly. This might be done not only in the case of various defoliating caterpillars such as those attacking paddy, cholam, castor, groundnut, palms, etc., but also with borers of sorts such as the stem, shoot and fruit-borers of various valuable crops. For this purpose, special cages or parasite boxes suited to each insect pest and its natural enemies could be devised; such boxes containing infested plants or portions of plants, which allow only the natural enemies to emerge, may be placed in the infested fields. Trials in this direction have been made by the Madras Agricultural Department with some success for the

* The following insect Pests in South India have been found attacked by the tachinids noted against each :—

1 The hawk moth *Acherontia styx—Sturmia atropivora*, R. D.
2 The fruit moth *Othreis—Winthemia albiceps*, M.
3 The sunhemp moth *Utetheisa—Padomyia setosa*, D.
4 The cut worm *Laphygma—Eutachinia civiloides*, S.W.
5 The ficus leaf worm *Phycodes—Sturmia painei*, B.
6 The tea slug *Heterusia —Exorista hetrusiae*, C.
7 The army worm *Spodoptera—Sturmia bimaculata*, *Tachinia fallax*, M., *Actia egyptia*, V., *and Pseudogonia cinerascens*, R.

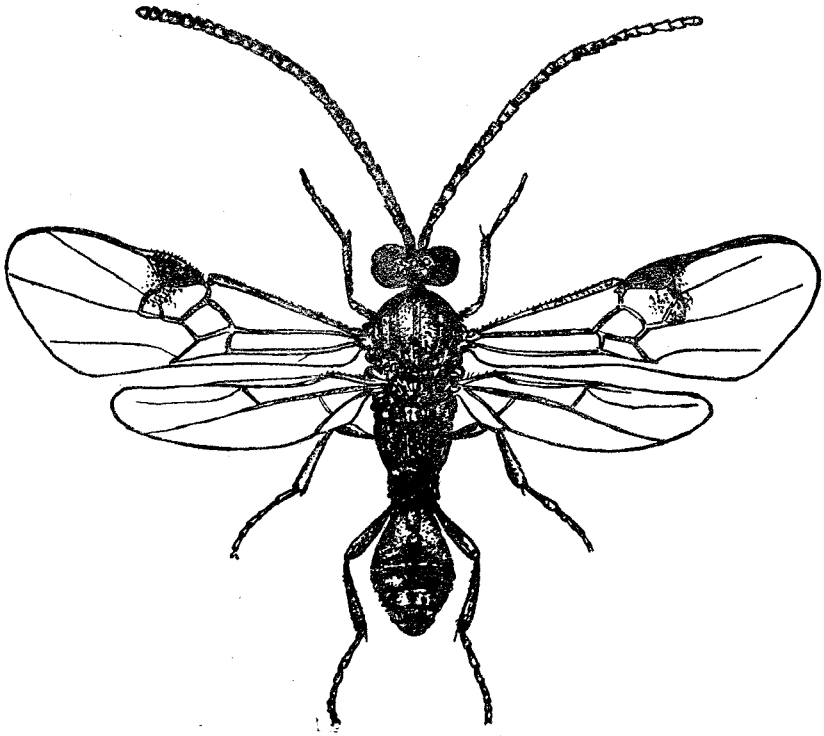


FIG. 69.—A PARASITIC WASP ON THE CASTOR SEMI-LOOPER.
(*Microplitis ophiusae* Ram.)

black-headed caterpillar (*Nephantis serinopa*) of coconut, a serious pest in some areas along the West Coast. Similarly in the case of many pests of which the egg masses can be easily found and collected, as in the case of the paddy stem borer, the tobacco caterpillar, hairy caterpillars of sorts on cholam, castor, etc., and various others where the eggs are laid in masses, these latter may also be kept to allow any of the egg parasites to emerge ; egg masses may with advantage be kept exposed on a tray of water or in the middle of an ant pan so that the egg parasites might fly away and any minute larvæ that might hatch out of unparasitized eggs might drown themselves if they attempt to crawl out. The stubble and debris of various borer-breeding plants like cholam, paddy, wheat, cane and various vegetable crops after harvest may

also be treated similarly to liberate any natural enemies that might breed in them. In these simple ways the existing parasites or predators in each tract might be helped to do their useful work more effectively ; on the other hand, when the collected pests or the pruned branches containing pests are buried or burnt; as is usually done, the natural enemies also get destroyed. The adoption of such simple methods described above will substantially supplement the ordinary mechanical measures of control generally adopted at present.

But when it comes to a question of adopting the biological method as a primary measure of pest control in cases where the ordinary mechanical methods are impracticable or uneconomical, arrangements of a more organized nature will be found necessary if substantial and sustained benefits have to be derived. Such is evidently the case when we have to fight pests spread over extensive areas, and insects like scales, borers, etc., on fruit and avenue trees some of which may be perennial. They cannot possibly be collected and brought together without great inconvenience and expense. To carry out a regular campaign of biological control, in the case of important crop pests, where the ordinary mechanical methods have proved unsuccessful, the most important thing necessary is in the first place, a plentiful supply of the predator or parasite ready for liberation in the infested areas. For, the liberation of only a few individuals has the disadvantage of these few separating from one another and spreading far away, thus preventing the chances of union of sexes and multiplication of the species ; in some cases there may not be present sufficient or any females in the small lot let out. In the simple methods described above of heaping collected material inside cages to liberate the natural enemies, we get absolutely no idea of the actual numbers liberated to form any correct estimate of the work of these natural agents. Another important factor that vitiates to a great extent the expected results of such simple methods, and which is overlooked very often, is the work of hyper-parasites, parasites which attack the primary natural enemies themselves, not an uncommon phenomenon in nature. A braconid wasp (*Aphrastobracon flavipennis*) which the writer discovered as a parasite of the useful scale feeding caterpillar (*Eublemma*) (fig. 70) is an example of such a secondary enemy spoiling the good work of friendly insect. Very often such complications in modes of parasitism come into play and affect the bionomics of a pest. This has been found to be the case with the coconut caterpillar pest (*Nephantis serinopa*) in South India where we have a complex in which over fifteen insects are found to interfere with the bionomics of this single insect as parasites, predators, hyper parasites, etc., etc., *vide* fig. 71. In the simple use of wire gauze cages it may not always be possible to keep back such secondary enemies and allow only the primary one to emerge. Yet another defect one has to guard against in such a measure is the probable contingency of the natural

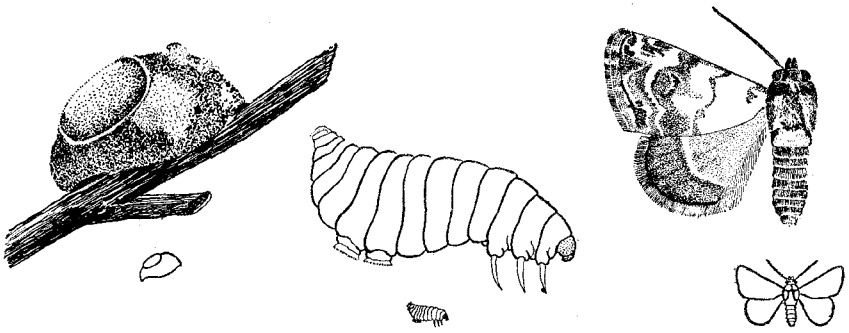


FIG. 70.—A PREDATORY MOTH ON SCALE INSECTS (*Eublemma scitula*, R.).
(Cocoon, larva and moth.)

[*From S.S.I.*]

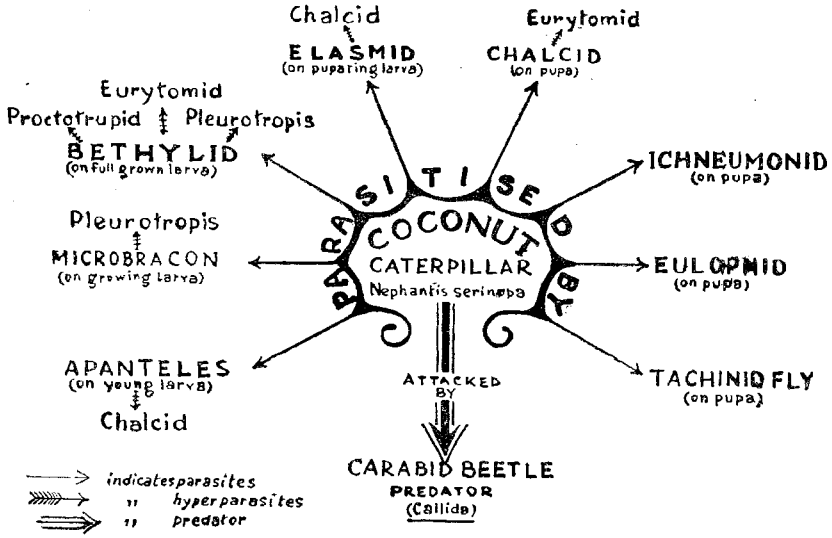


FIG. 71.—PARASITIC COMPLEX OF THE COCONUT CATERPILLAR.

enemy being starved or destroyed when liberated in any tract, either for want of sufficient food or becoming subject to sudden and unusual climatic changes which might in some unfortunate cases affect the natural enemy very seriously. To guard against these and other incidental defects the best thing to do so is to have these parasites and predators of known capacity reared in large numbers in field laboratories or insectaries under the supervision of skilled hands, and then distributed in batches to different infested areas whenever necessary. The study and elimination of hyperparasites, the question of sufficient food supply, protection from weather conditions, all these may be carefully attended to in captivity. The ideal natural enemy to be selected for such use should be

one which would breed easily and plentifully in captivity, which has no enemies of its own and which would attack its host in any stage. This is the sort of work that is being carried on in countries where biological methods of pest control have advanced to some extent. Such insectaries or field laboratories will not only help in affording the necessary facilities for the proper breeding and distribution of the natural enemies already studied as a routine, but would serve as institutions where all sorts of investigations and experiments could be safely and accurately carried on with various local and introduced insects of economic importance.

We now come to the subject of introduction of natural agents from one country to another, as distinct from the conservation of native beneficial forms. This aspect of the question is far more important in countries where a good number of cultivated crops are foreign, and the insects on that account mostly exotic and introduced with the former; these latter, deprived of their original natural checks in their new homes, often multiply remarkably and become serious pests. In such cases, attempts should be made to locate the original home of the pest and bring such of its natural enemies found there which keep it in control. As such, Australia, including many other colonies in the Pacific, South Africa and many parts of the New World are the regions chiefly interested in such search and importation of these natural agents. The most remarkable of such pioneer attempts is the well-known introduction of the famous lady-bird beetle (*Rodolia cardinalis*, M., fig. 72) in 1889 by Koebele from Australia to California to fight the cottony cushion scale (*Icerya purchasi*, M., fig. 73) a very destructive pest of citrus trees in different parts of the world. As a result of the phenomenal success of this introduction this predatory lady-bird beetle

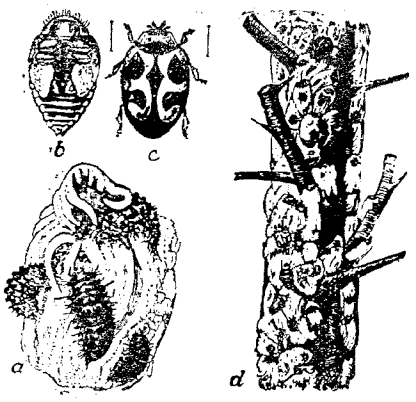


FIG. 72.—THE PREDATORY LADY-BIRD BEETLE.

(*Rodolia cardinalis* of Australia attacking the cottony cushion scale.)

a, *b* & *c* Larva, Pupa and adult.

d Scale infested twig with lady-bird.

[*After Marlatt*]

was taken to various other countries like Portugal, South Africa, Italy, Hawai, Farmosa, etc. Even in South India where this scale pest has somehow got in, the use of the lady-bird beetle was tried with some substantial success during the years 1927–30. In this connexion it may also be added that as a result of the introduction and distribution of the cochineal insect enemy of prickly-pear, the spread of this well-known plant pest has been remarkably and very appreciably checked in different parts of India within recent years. It cannot be said that such attempts may not be necessary or useful in India; it is quite possible that there may exist somewhere outside our country effective natural agents keeping in check pests which are the same or very similar to some of our own serious forms, and in such cases, it would certainly be worth our while to introduce such forms and give them a trial.

Legislative measures for pest Control.—Properly speaking these measures are mostly of a preventive nature as has been referred to before. Legislative enactments are made by Governments when it is found that some insect or other important pests are likely to be transferred from place to place and helped in getting distributed in areas where they did not exist before. Examples of some important and undesirable insect aliens from which we are luckily free so far are the Mediterranean fruit fly, the grape-vine Phylloxera, the Mexican cotton boll weevil, etc., etc.; the Codling moth and the San Jose Scale (fig. 74) two insects which were also regarded as unwanted forms have been recently regarded in parts of India as our prospective serious pests. The coffee berry borer *Chryphalus* (fig. 75) is a bad pest of coffee in some countries outside India. And in these days of easy facilities for rapid and easy transport there are chances of undesirable insect and other foreign pests getting entry into the country and add to our already existing pests. To avoid such contingencies, Governments of various countries have resorted to legislative measures. The most important of such enactments are (1) Acts to prevent the entry of a foreign pest which is absent in the country from gaining admission into it, (2) Acts to prevent any important pest which already exists in one part of a country from getting distributed to the other areas of the country which are free from it. Since 1919, we have a Pest Act of the latter kind in the Statute Book of the Madras Government and this is being enforced as necessities arise as in the case of the red hairy caterpillar, cotton pests and the coconut caterpillar. When once these measures are enforced and people appreciate their value, other enactments like the compulsion to carry out certain well-known and effective remedial measures, compulsory quarantine and fumigation of plants and seeds for transport from place to place, insecticidal laws, etc., would also go a great way in minimizing the multiplication of pests and consequent loss by damage. Such legislative measures have gone a long way to check some serious

crop pests in other countries. It may be interesting to note that in appreciation of the timely warning given by the notorious Mexican cotton boll weevil (*Anthonomus grandis B*), a monument has been erected in its honour in Enterprise city Alabama State U.S.A. with the inscription "In profound appreciation of the 'boll weevil' and what it has done as the herald of prosperity."

FIG. 73.—CLUSTERS OF THE COTTONY CUSHION SCALE (*Icerya purchasi*) ON ORANGE TWIG.

[*After Essig*]

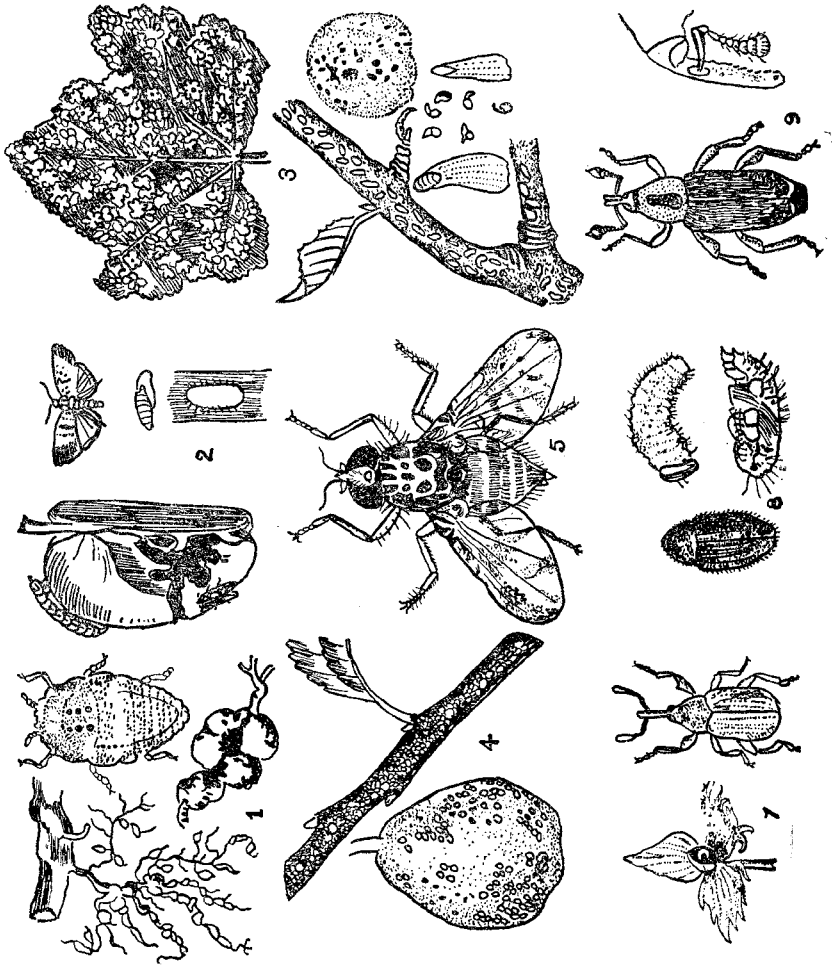


FIG. 74.—SOME NOTORIOUS FOREIGN INSECT PESTS.

1 & 3 Grape-vine Phylloxera; 1 shows root form and 3 the leaf nodules. [*After Marlatt*]

2 The Codling moth (*Carpocapsa pomonella* L.) on damaged apple and different stages of the moth. (*From U.S.A. Bulletin.*)

4 The San Jose Scale (*Quadraspidiotus perniciosus* C.) on pear. (*After French*).

5 The Mediterranean fruit fly (*Ceratitis capitata* W.) magnified. (*From insect life*).

6 The Oyster shell scale (*Lepidosaphes ulmi* L.) on apple. (*After French*).

7 The cotton boll weevil (*Anthonomus grandis* B.) grub in boll and weevil.

8 The small sweet potato weevil of Hawaii—beetle, grub and pupa (*Cryptorhynchus batatae*). (*After Fullaway.*)

9 The West Indian Sugarcane beetle. (*Rhabdoanemis obscurus* B.) [*From Insect Life*]

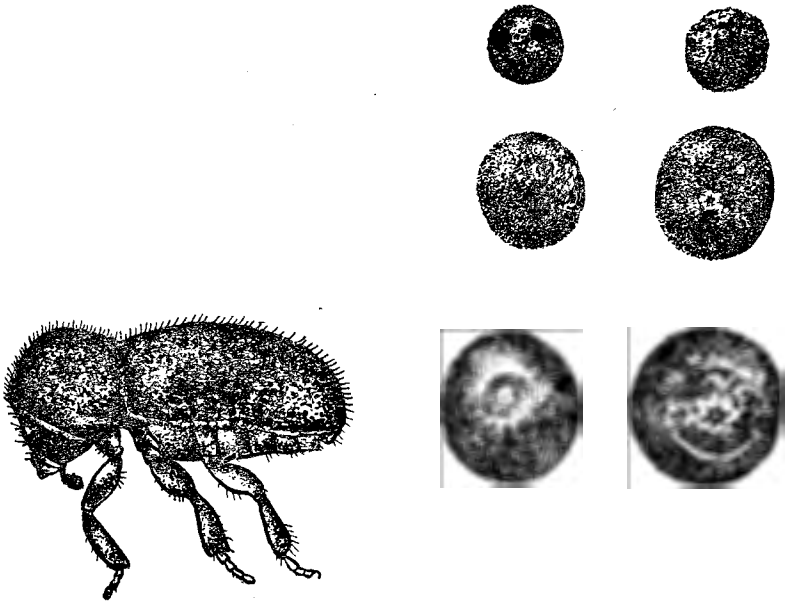


FIG. 75.—THE COFFEE BERRY BORER BEETLE *Chryphalus hampei*, F., AND BORED BERRIES.

[After Leefmans]

CHAPTER X.

Insect Pests of Cultivated Plants—Categories.

Nature and range of insect damage—Incidence and periodicity of pests—Insect pest calendars—Different categories of insects affecting plants.

There is hardly any cultivated plant which escapes the attentions of some insect or other though it may be found that some plants are more susceptible to their attacks than others. It is also found that among plant-feeding insects, while a few of them depend for their food almost entirely on one plant (*Monophagous*), or only a few closely allied food plants (*Oligophagous*) there are many others which are not so fastidious as regards their food and are found feeding on more than one food plant (*Polyphagous*). The paddy stem borer (*Schoenobius*) and the prickly-pear cochineal (*Dactylopius*) are examples of the former and the cut worms (*Prodenia* and *Heliothis*) are typical polyphagous insects. As to the nature of the damage caused to plants, it will also be found that no part of a plant is free from insect attack and that every portion of it has its peculiar insect associates ; the roots, stem, bark, shoots, leaves, flowers, seeds and fruits have all their characteristic insect pests. Nor is it rare to find insects of sorts visiting or temporarily remaining on plants either as mere visitors or as minor pests. Under these circumstances, it will be very advantageous if every cultivator gets to know in the first place which insects are his enemies, and which are not ; and of the former, he might note those which constitute the major or important pests and those which are of minor importance. These are essential pre-requisites before one attempts to devise the possible control measures suited to each as the necessity arises. By gradual experience, in observing and noting the different forms of the damage caused to his crops by diverse insects the farmer will be in a position to more or less make out correctly even from the external indications of the damage done, which the particular kind of pest is. Nor will he find it difficult in course of time to foresee as to the season or seasons when he might expect particular pests of different crops. In this way, experienced farmers of each different tract will be in a position to prepare insect pest calendars suited to any area and thus, be not only well prepared to meet insect pests when they appear, but even be fit to prevent their appearance by methods adopted sufficiently early (see Frontispiece and figs. 76–77). In the same way, cultivators of special crops also come to know by experience as to the particular stage or stages in the growth of their crop when they can expect a particular kind of pest (see fig. 78).

Before dealing with the important specific pests of different cultivated plants one after the other, it might be advantageous to briefly examine insects affecting plants in a general way from the

CALENDAR OF IMPORTANT PESTS OF CHIEF CROPS OTHER THAN PADDY.

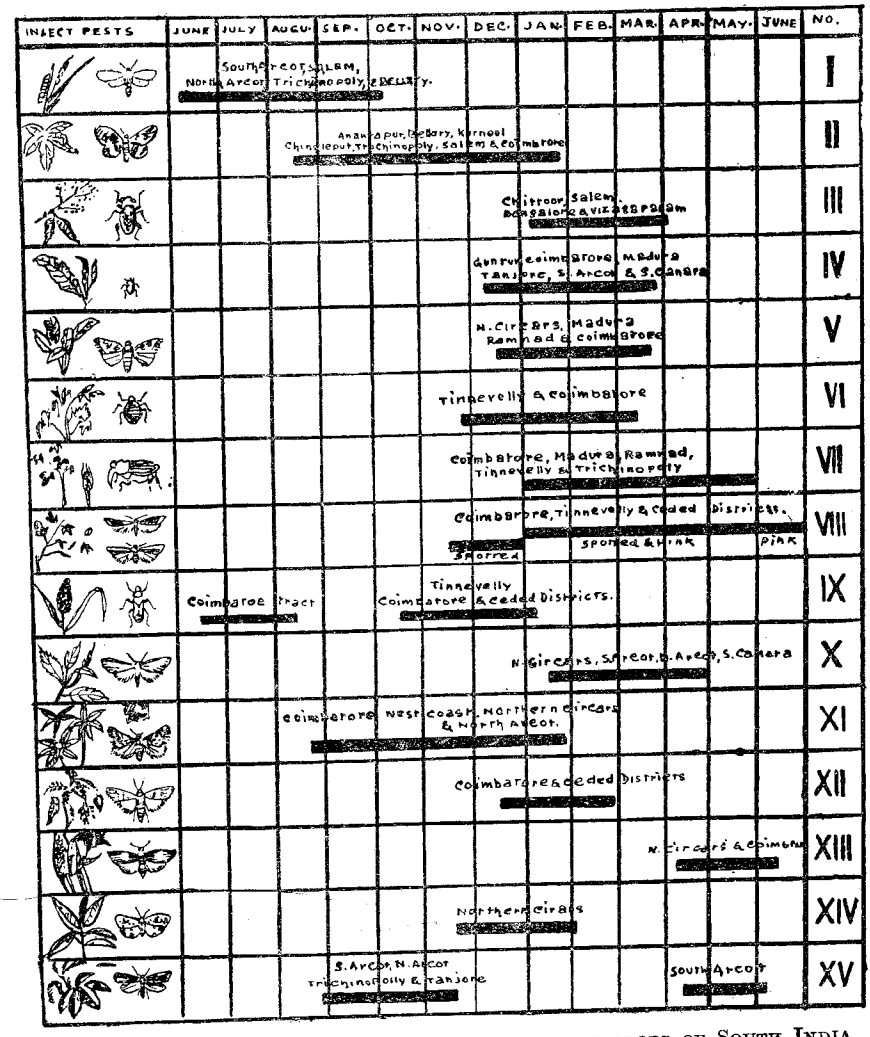


FIG. 76. CALENDAR OF IMPORTANT PESTS OF CHIEF CROPS OF SOUTH INDIA OTHER THAN PADDY.

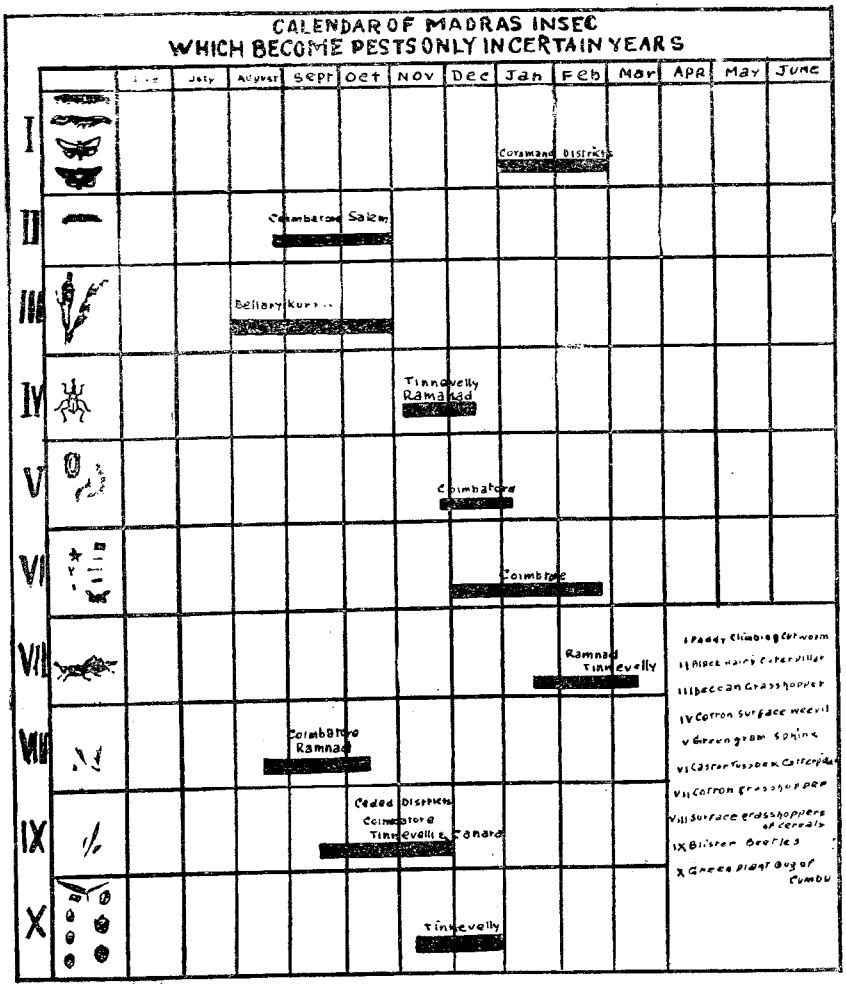


FIG. 77.—CALENDAR OF SOUTH INDIAN INSECTS WHICH BECOME PESTS ONLY DURING CERTAIN YEARS.

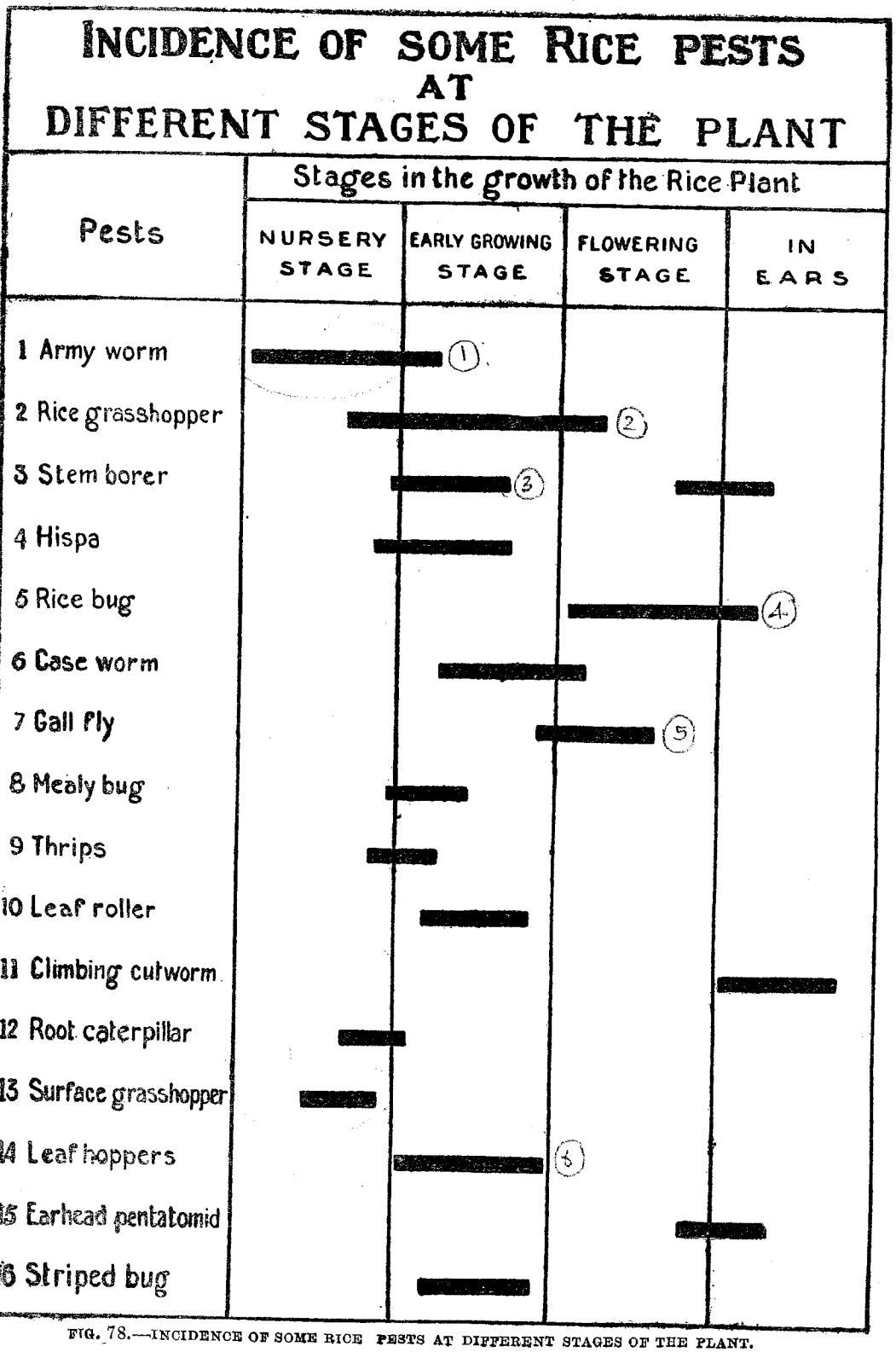


FIG. 78.—INCIDENCE OF SOME RICE PESTS AT DIFFERENT STAGES OF THE PLANT.

point of view of their feeding habits and the different ways in which they cause damage to plants and to deal with them under some convenient categories ; though many of the forms included in each of these different categories might belong to different natural orders of insects it will be found that their habits are similar and that they could be checked in many cases by similar control measures. The following are the more important of these categories of pests and practically any important pest of most crops will fall into one or other of these groups. More information on these pests can be found in the following chapters :—

(1) *Plant lice* (*Aphididae, fig.* 79).—Very few cultivated plants escape the attentions of one or other kind of plant louse. These are minute slow moving soft creatures generally without wings ; each insect has the characteristic pair of tube-like structures (*cornicles*) on the postero-lateral region of the abdomen. These insects are bugs and suck up the plant sap from the tender parts of the plant by means of their needle-like sucking tube. They are often found in numerous colonies clustering over the tender parts of various plants. Due to sap drainage the affected parts of the plants fade and dry up often causing serious damage. These have the habit of exuding a sweet fluid '*honey dew*' which attracts numerous insects, especially ants. This honey dew very often covers the foliage and these latter become covered with sooty blight. Among plants which are generally subject to the attacks of plant lice may be mentioned cotton, cholam, lab-lab, cow-pea, cabbage and many vegetables, citrus and other fruit trees like mango, jack, pomegranate, etc., tobacco, rose and many other garden and flowering plants.

Plant lice multiply very rapidly—often by the process of *Parthenogenesis*, and winged members are only occasionally seen among the colonies. Plant lice of different kinds can be easily checked by the application of contact insecticides like crude oil emulsion, tobacco decoction, fish-oil soap, etc. In many cases, their natural enemies which chiefly include lady-bird beetles, syrphid flies and chrysopids are found among the colonies checking the abnormal multiplication of the lice.

(2) *Scales, mealy bugs and mealy wings.*—This category includes a number of small bugs which are found in colonies on various plants similar to plant lice and causing the same kind of damage to them. In structural characters, however, there are differences between plant lice and these bugs. Unlike the plant lice, for part or whole of their lives some of these insects remain stationary and do not move ; there are also striking sexual differences among the scales and mealy bugs. Scales and mealy bugs included in the family (*Coccidae*) and the mealy wings (*Aleurodidae*) are some of the worst pests of fruit trees and garden plants all over the world and especially in the tropics (figs. 80, 81 and 82). Among

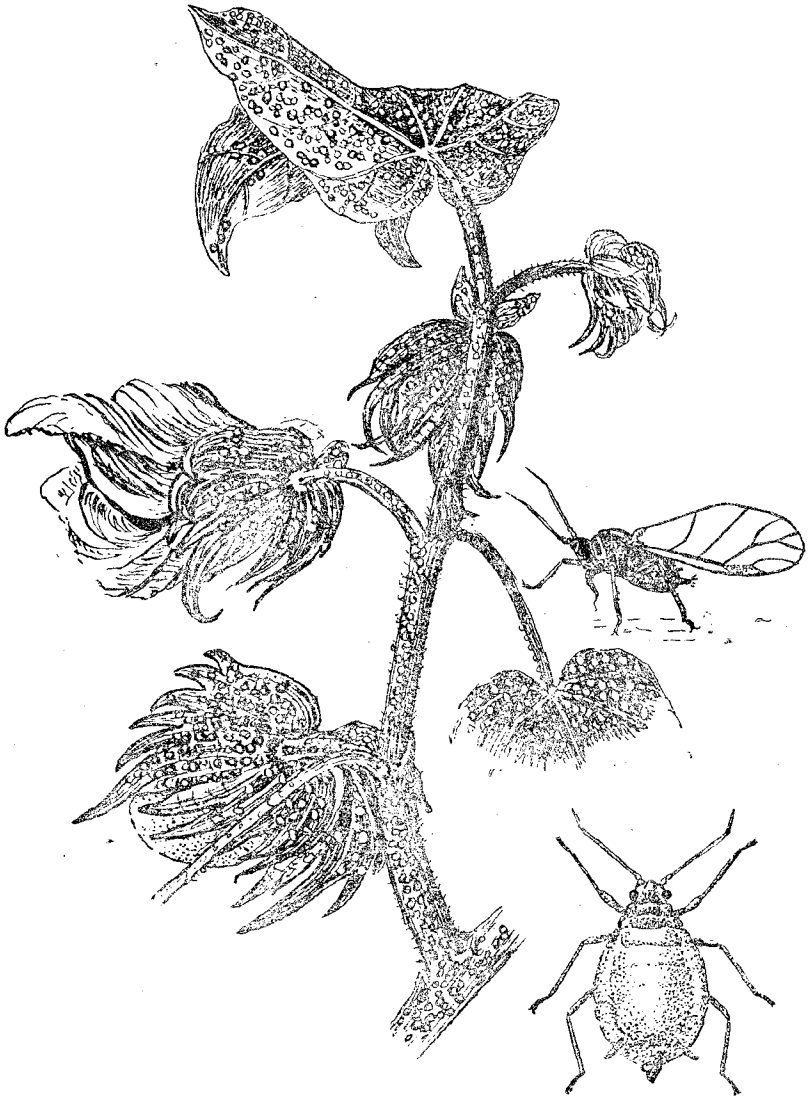


FIG. 79.—PLANT LICE ON COTTON (*Aphis gossypii*. G.).

the familiar pests of this group in South India are the mealy bugs and mealy wings of sugarcane (*Trionymus sacchari* and *Aleurolobus barodensis*), the paddy mealy bug (*Ripersia oryzae*), the citrus mealy wing (*Aleurocanthus spiniferus*), the green scale of coffee (*Lecanium viride*), the mealy bug of garden crotons (*Icerya aegyptiaca*), the tamarind scale (*Aspidiotus tamarindus*), the pepper vine scale (*Lepidosaphes piperi*), the mango mealy bug (*Phenacoccus mangiferae*)

the nim tree scale (*Pulvinaria maxima*) and the castor mealy wing (*Trialeurodes ricini*). The treatment for these insects is similar and consists chiefly of pruning and destruction of badly infested parts of the plant and the application of strong contact insecticides. The insecticides generally used are fish-oil rosin soap, crude-oil emulsion and rosin soda wash. It will also be found that control of ants which help in spreading scale insects and mealy bugs from plant to plant will also be found to be an indirect control measure against the latter. In many countries, the method of controlling these insects by utilizing their natural enemies like lady-bird beetles, parasitic wasps, etc., "(*Biological control*)" is now becoming popular.

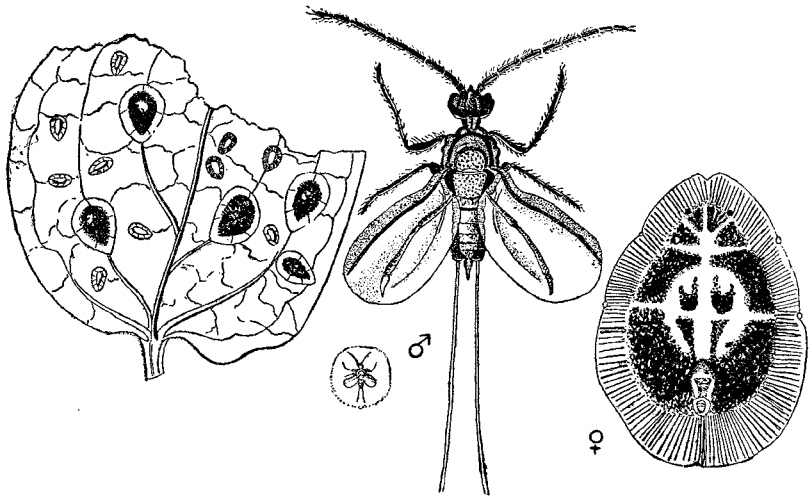


FIG. 80.—SOFT SCALE ON PEPPER LEAF (*Marsipococcus marsupiale, G.*), MALE, FEMALE AND INFESTED PEPPER LEAF.

[*After Green.*]

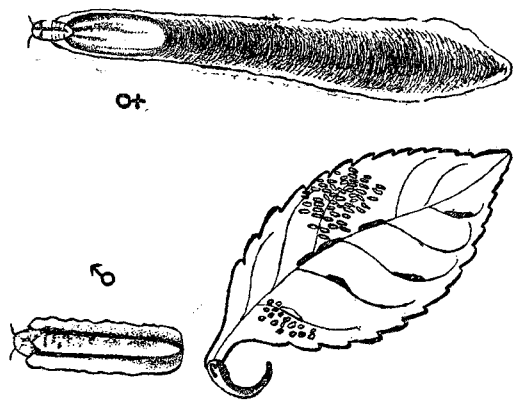


FIG. 81.—HARD SCALE ON TEA PLANT (*Hemichionaspis theae, G.*)

[*After Green.*]

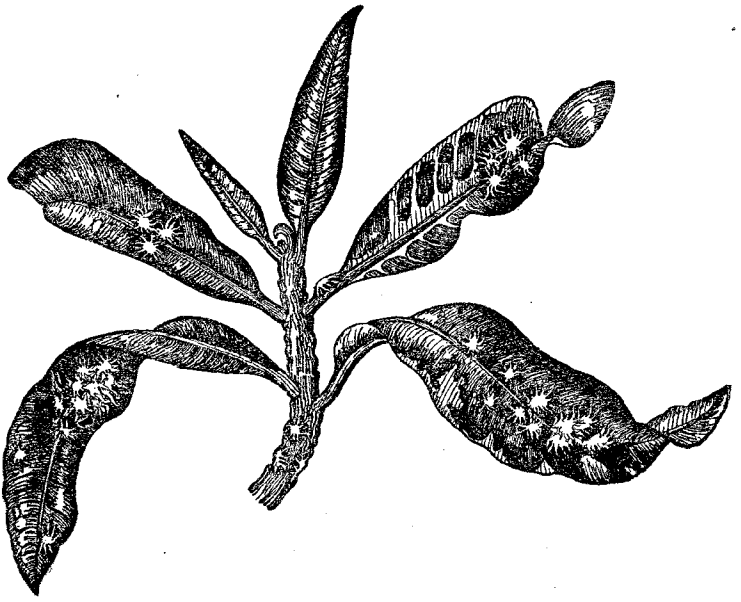
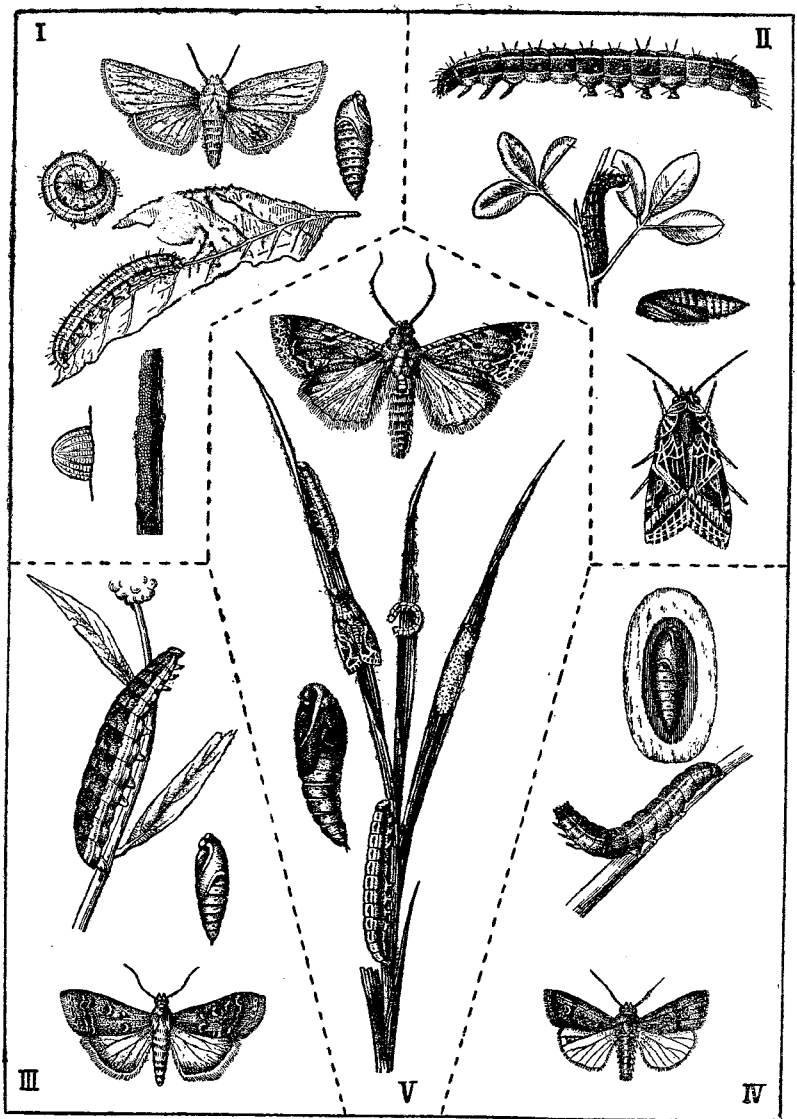


FIG. 82.—MEALY BUG ON CROTON (*Icerya aegyptiaca*, *D.*)

(3) *Surface insects.*—These are forms which generally damage the very young plants which are just emerging from the soil surface after seed germination. They generally live on the soil surface and many of them have the habit of hiding themselves during the daytime. These include cutworms. grasshoppers and surface beetles. *Cutworms* (Noctuidæ): During the very early stages of a crop, the gardener often finds during the morning young plants, which were healthy the previous evening, cut off near the surface of the ground; this is generally done by what are known as cutworms (fig. 83). These are smooth cylindrical caterpillars of stout, dark brown moths which occasionally cause serious damage to very young crops. They hide under the soil during the day and are active by night. When disturbed, they can roll up like millipedes. They are found on cabbage, chillies, onions, brinjal and many other crops. When in numbers, they often move in groups from field to field and cause considerable damage. After feeding they pupate in the soil and emerge as moths to start a fresh generation. Some of them attack grown-up plants also when they are known as climbing cutworms. Well known among the cutworms are the tobacco caterpillar (*Prodenia*), the ragi worm (*Laphygma*), the climbing cutworm of paddy (*Cirphis*), the potato cutworm (*Euxoa*) and the paddy army worm (*Spodoptera*). *Grasshoppers and surface beetles.*—Some grasshoppers and beetles have also the same feeding habits as cutworms though they are very rarely so destructive. Examples of plants which occasionally suffer from



I (Climbing) cut worm of Paddy & Grasses (*Cirphis albistigma, M*)
II Cut worm of tobacco, tomato, castor etc (*Prodenia litura, F*)
V Army worm of Paddy & Grasses
III Cut worm of Onions, chillies etc (*Laphygma exigua, Hb*)
IV Cut worm of Potatoes (*Euxoa segetum, S*) (*Spodoptera mauritia, B*)

FIG. 83.—CUT WORMS.

these surface pests are cholam, ragi, paddy, cotton, tobacco, chillies and various vegetables. Sometimes nurseries of plants become badly infested. Some of these insects often possess the peculiar protective coloration of the soil on which they are generally found and thus escape notice. One of the best methods to deal with these is the mechanical one of netting and bagging the creatures. In bad cases, poisoned baits can also be employed. (*See* Appendix C.) Among surface grasshoppers, the commonest are species of the short stout soil grasshopper (*Chrotogonus*—fig. 84) found on all dry crops, and the other nursery grasshoppers like *Aelopus* (fig. 110), *Atractomorpha* (fig. 287), *Orthacris* (fig. 126), etc. Other well-known grasshopper pests are the Locusts and the Rice grasshopper, etc. Surface beetles include some small flea beetles, ground weevils, the cotton weevil (*Atactogaster*) found in the southern districts and the dark ground beetles (*Gonocephalum*, *Opatron*, *Seleron*, etc.—fig. 204) attacking grapevine, tobacco, potato, etc., in some areas.

(4) *Underground insects.*—Well-known forms under this category are the crickets (*Gryllidæ*—fig. 85), the termites (*Isoptera*), the ants (*Formicidæ*), the wire-worm beetles (*Elateridæ*) and the white grubs (*Melolonthidæ*). Crickets are familiar nocturnal insects found in irrigated fields, damp gardens and vegetable plots often cutting the roots of young plants. Wire-worms are the elongate ribbon like larvæ of what are known as "click beetles" (fig. 86). These larvæ are occasionally found doing damage to underground roots of plants and tubers of potato and other plants; they are not so commonly found in India as in other parts of the world. Termites are the well known white ants which are more serious as dry timber and domestic pests than as crop pests. Among the crops usually found suffering from termites important ones are sugarcane, groundnut, grapevine, wheat, etc. Ants are better

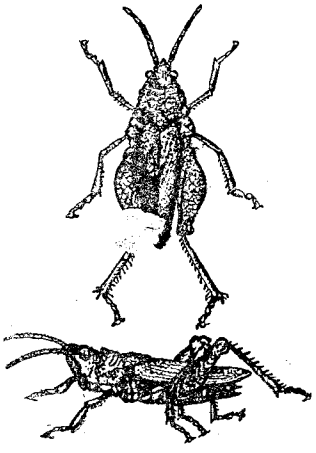
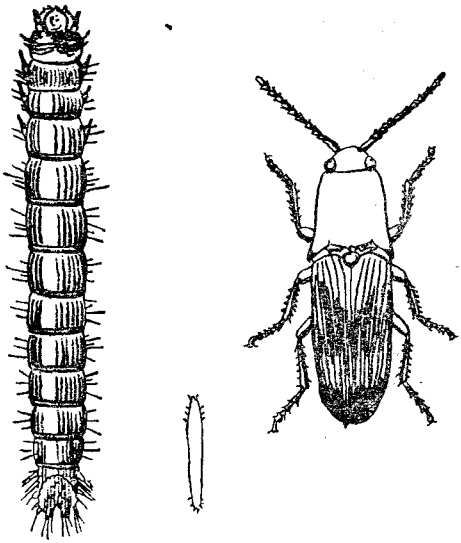


FIG. 84.—SURFACE GRASSHOPPERS (*Chrotogonus robertsoni B.*)

FIG. 85.—MOLE CRICKET.
(*Gryllotalpa africana, K.*)
[*After Lefroy.*]



(*a*) (*b*)

FIG. 86.—(*a*) WIRE WORM LARVA AND (*b*) ADULT-CLICK BEETLE.
(*Drasterius sp.*")
[*From Rept 3" Ent. meeting.*]

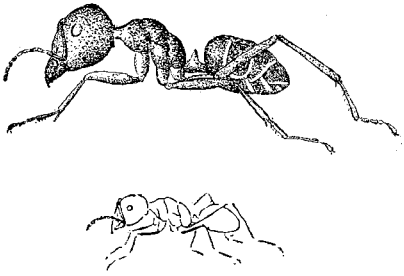


FIG. 87.—THE COMMON BLACK ANT.
(*Camponotus compressus L.*)
[*After Lefroy.*]

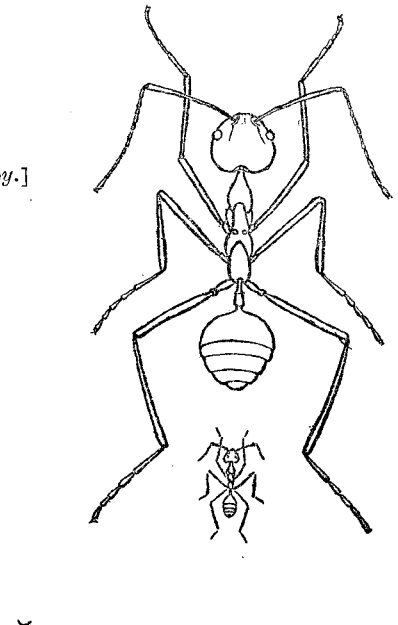


FIG. 88 (1).—THE RED TREE ANT.
(*Oecophylla smaragdina, F.*)
[*From S.S-I.*]

FIG. 88 (2).—RED ANT CHAMBER ON TREE.
[*From S.S.I.*]

known as domestic pests. In the fields though very few actually cause harm to growing plants (*Dorylus* and *Solenopsis* on canes, brinjal, etc.), they are more responsible for the dispersal from plant to plant of the bug pests like the plant lice, scale insects and the other small bugs which supply them with honey-dew. The notorious red ant (*Oecophylla smaragdina F.*) is very conspicuous in this manner on many fruit trees in different parts of the province (fig. 88) and the common black ant (*Camponotus compressus L.*) (fig. 87) causes harm by distributing plant lice to various growing plants like ragi, cholam, cotton, etc. *White grubs.*—These are underground creatures and the larvæ of beetles known as cockchafers. These larvæ have sordid white colour and a stout curved fleshy body (fig. 89). Every farmer is familiar with these grubs which are found in manure heaps and which often come up behind the plough attracting birds which greedily feed on them (fig. 413). While the grubs cut off the roots of tender plants of various kinds, the adult cockchafers generally defoliate plants during the night as in the case of the rose, grape-vine and garden plants. These beetles often come to lights especially after a rain. Prominent among our chafers are the coconut rhinoceros beetle and the various chafer species of *Holotrichia*, *Anomala*, *Serica*, etc., which often come to lights (fig. 89).

All these underground insects can be checked in different ways. Efficient cultural methods like deep ploughing, destruction of cricket burrows and nests of termites in the fields and in the vicinity, mixing irrigation water with disinfectants, flooding, etc., will go a great way in checking these pests. Light traps will attract the adults (cockchafers) of white grubs, and during certain seasons swarms of these beetles can be collected near lights especially on the hills. Periodical irrigation with crude oil impregnated water will also suffocate and drive away white grubs and white ants from the soil.

(5) *Leaf caterpillars.*—We now come to the insect pests of plants which have grown and risen up from the ground surface. One very important group of such insects is that of leaf caterpillars. These, of course, include different kinds such as hairy, spiny, smooth, sluggish, horned, etc. Hairy and spiny caterpillars—These form characteristically distinct groups of lepidopterous larvæ ; they have the body protected with a wooly covering of hairs or spines in various patterns and in some cases with both hairs and spines (fig. 90). The important species of such caterpillars in South India include the notorious red hairy caterpillar (*Amsacta albistriga*), the black wooly bear (*Estigmene lactinea*), the sunnhemp hairy caterpillar (*Utetheisa lo rix*), the black hairy caterpillar of castor and banana (*Pericallia ricini*), the sweet potato hairy caterpillar of Malabar (*Diacrisia obliqua*), the tussock caterpillars found on various crops like redgram, castor, gogu, babul, etc. (*Euproctis spp.*), the moringa hairy caterpillar (*Eupterote mollifera*), the castor slug

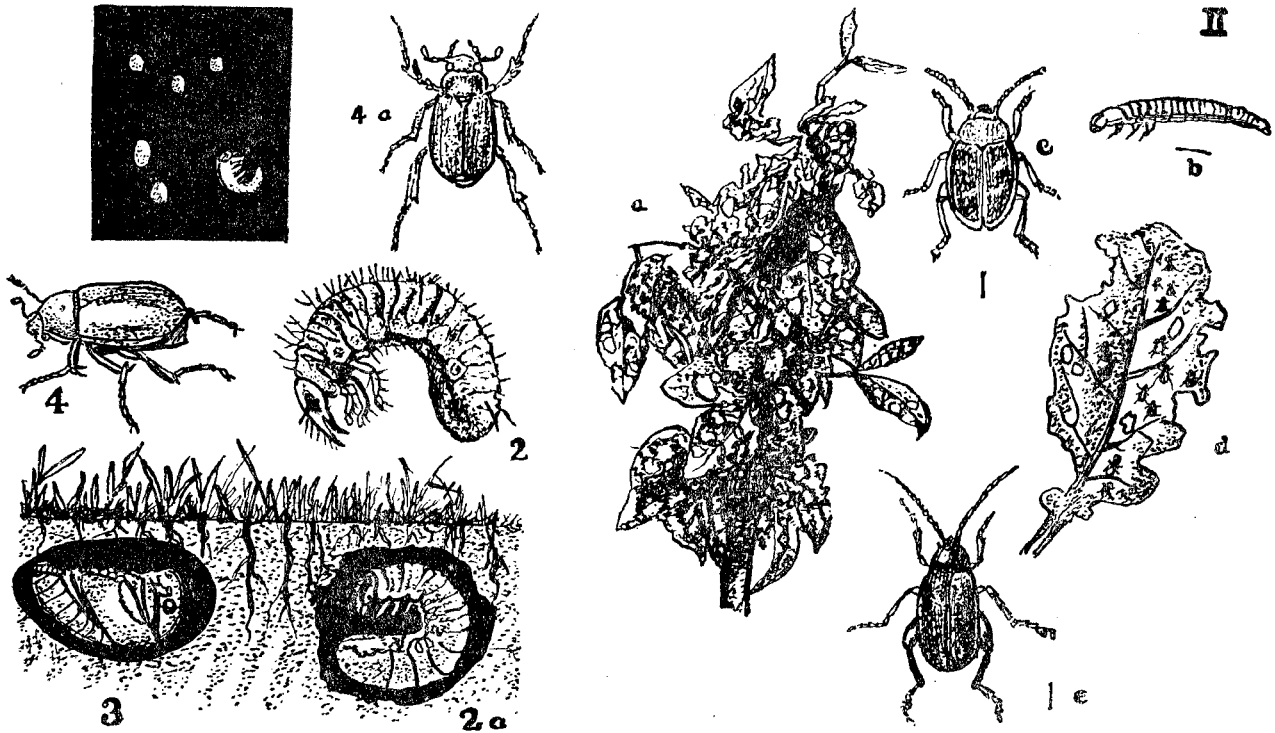


FIG. 89.—COCKCHAFERS AND FLEA BEETLES.

I Cockchafer stages—1, 2 & 2-A Egg—Grub ; 3 Pupa ; 4 & 4-A Adults.

II Flea beetles—*a* **Damage** on plant ; *b* Grub ; *c* & *e* **Adults**, *d* Beetle on leaf.

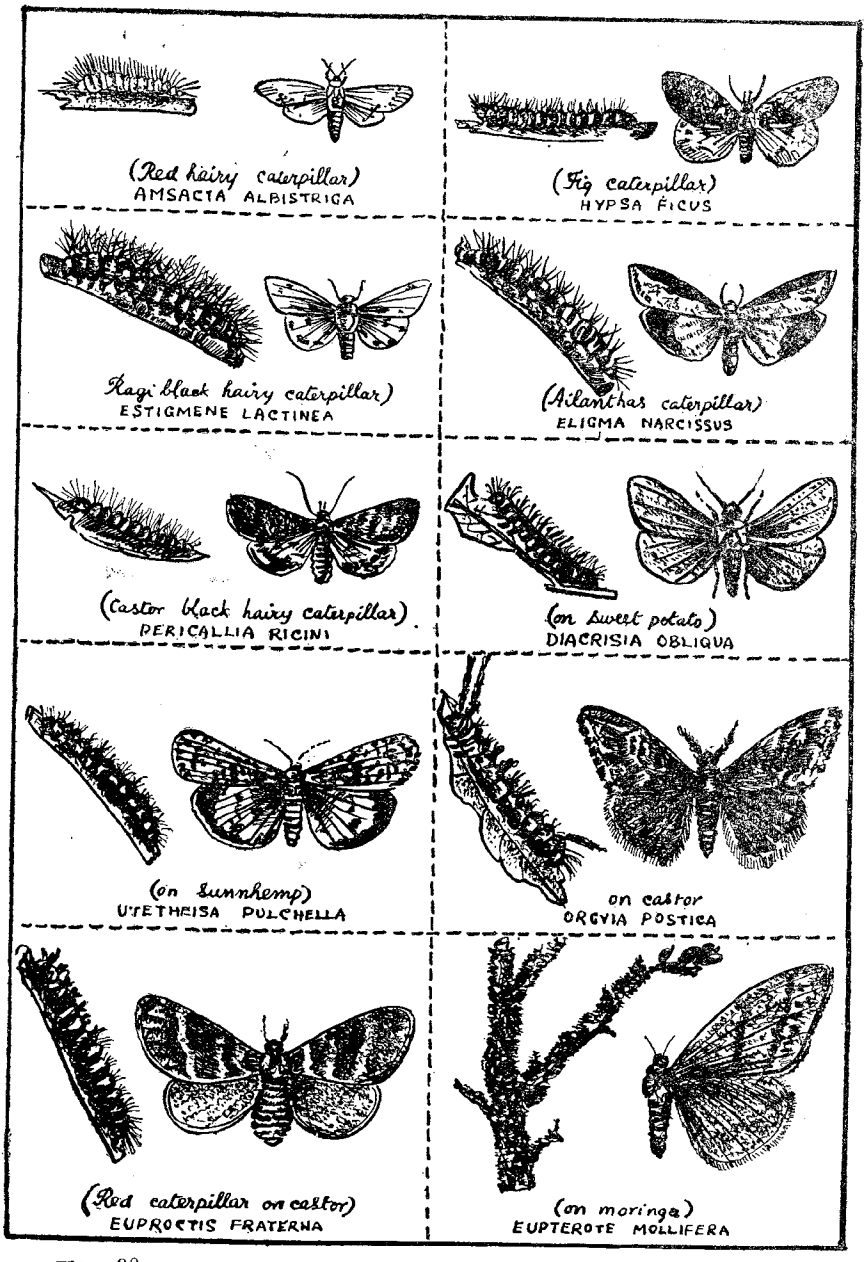


FIG. 90.—SOME SOUTH INDIAN HAIRY CATERPILLARS AND THEIR MOTHS.
[*From author's paper*, 1939.]

(*Latoia lepida*) and the nettlegrubs of coconut (*Contheyla* and *Natada*). The above are all moth caterpillars; some butterfly larvæ are also covered with spines and the important ones among these are the horned caterpillar of paddy (*Melanitis ismene*), the castor butterfly (*Ergolis merione*) and the mango leaf butterfly (*Euthalia garuda*). The control of these protected caterpillars depends upon the life history and habits of the different forms. The capture of the just emerged moths by handpicking or light traps, collection of egg masses, sweeping the caterpillars into baskets, destruction of alternate food plants and ploughing up of the pupæ under the soil form some of the more feasible and economical methods which could be adopted against some of the well-known hairy caterpillars. For some of the gregarious caterpillars like the moringa *Eupterotid*, the slug caterpillars or the tussock larvæ, clipping of the portions of the plant on which swarms of the larvæ feed together will be found very easy and practicable. In the case of the sunnhemp caterpillars besides mechanical methods, use of stomach insecticides on the infested crop and light traps have occasionally given some relief.

Other leaf caterpillars include various forms which exhibit special habits; examples are leaf rollers, leaf folders, leaf miners, leaf webbers and bag worms. The cotton leaf roller (*Sylepta derogata*), the brinjal leaf folder (*Eublemma olivacea*), the leaf miner of groundnut (*Stomopteryx*), the brinjal leaf webber (*Psara bipunctalis*) and the bag worms found on castor, tamarind (*Chaliodes vitrea*, H., and *Pteroma plagiophleps*, H.), etc., are well-known examples. The group including what are known as sphinx caterpillars are stout built larvæ with an anal horn, the adults of which are stout creatures known as 'Hawk moths'; the eggs and larvæ of these are very conspicuous on the plants (fig. 91). The familiar ones include the gingelly and lablab sphinx (*Acherontia styx*, W), the sweet potato horn worm (*Herse convolvuli*, L.) and the oleander hawk (*Deilephila nerii* L.). In many of these cases of leaf caterpillar attack mechanical methods of collecting or clipping off of the affected leaves will be found far more practicable, since insecticides do not generally penetrate the folds and mines in which some of these caterpillars often remain feeding.

(6) *Leaf, shoot and flower beetles.*—Similar to caterpillars different kinds of beetles feed on the foliage of cultivated plants. Of these, the commonest ones are the chafer beetles already noted before as adults of white grubs, weevils of different kinds, the epilachna beetles, blister beetles and several members of the beetle family Chrysomelidæ including what are known as the leaf and flea beetles. The weevils include the grey weevils (chiefly the genus *Myllocerus*) found on cholam, groundnut, etc., the field bean weevil (*Episomus lacerta*), the shoot and bud weevils of cotton redgram, agathi, etc. (chiefly species of *Alcidodes*) and the palm weevil (*Rhynchophorus*). The leaf beetles include such forms as the pumpkin

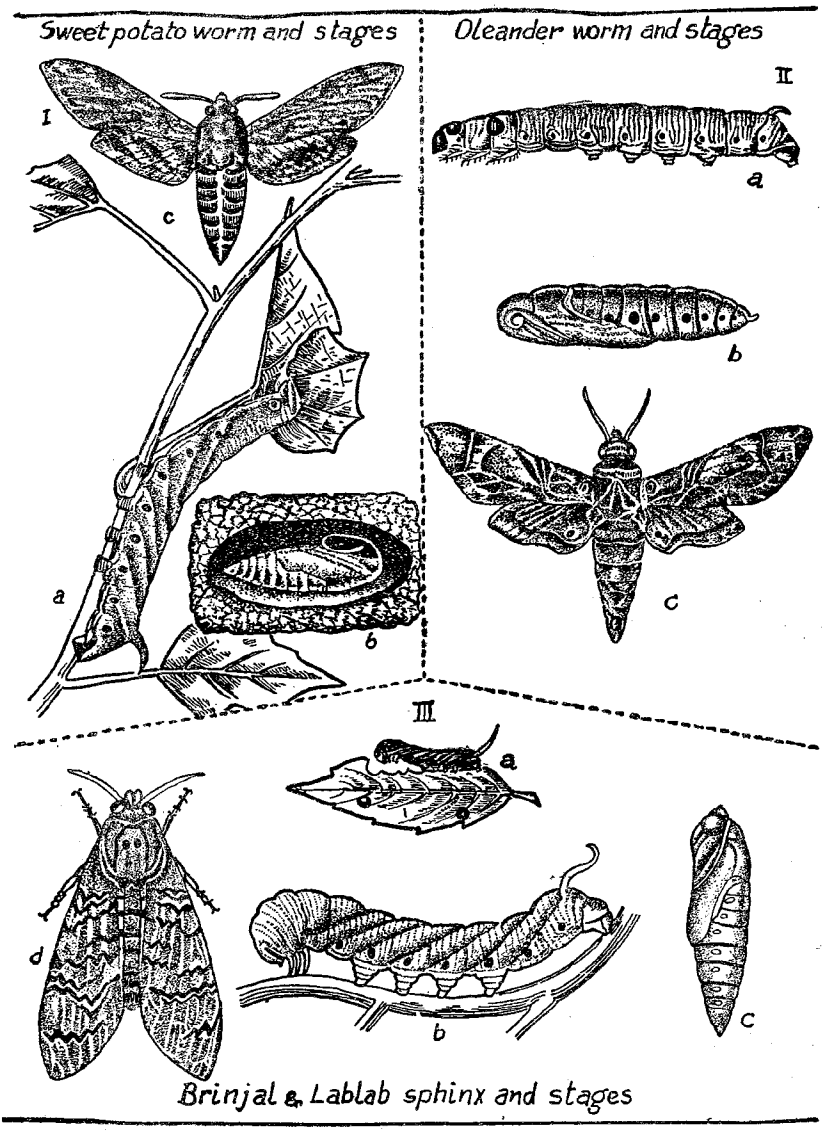


FIG. 91.—SOME HAWK MOTHS AND THEIR STAGES.

I Herse convolvuli, L, II Deilephila nerii L, III Acherontia styx W.

[*From author's paper* 1938.]

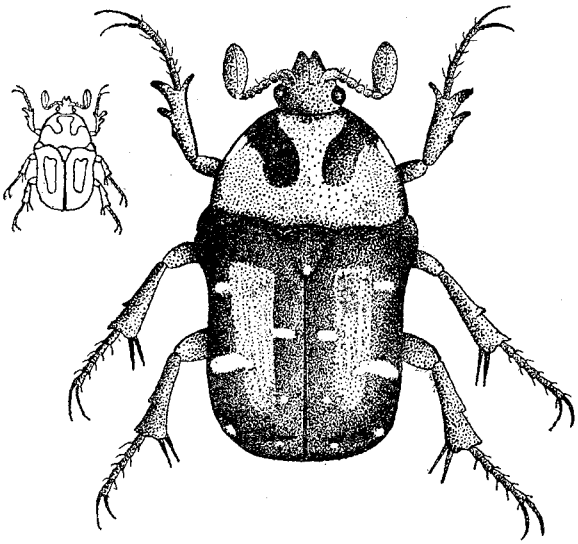


FIG. 92.—CHAFER BEETLE.

(*Oxycetonia versicolar F.*)

[*From S.S.I.*]

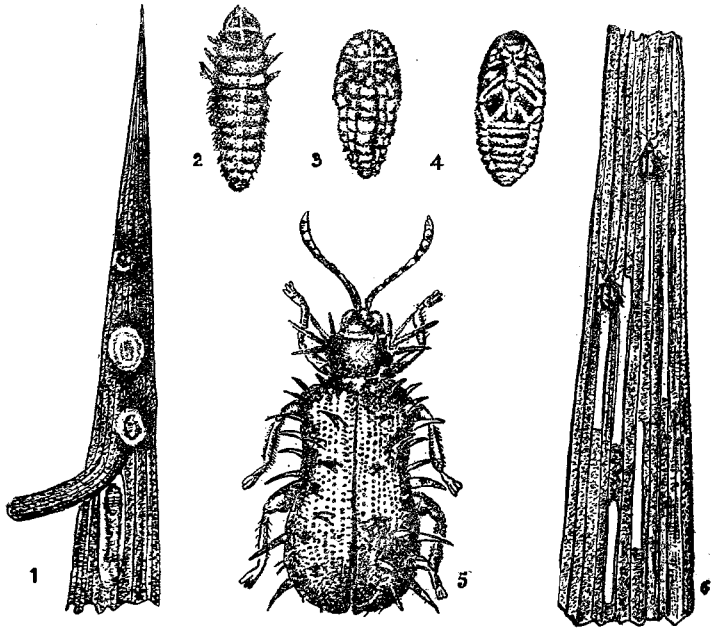


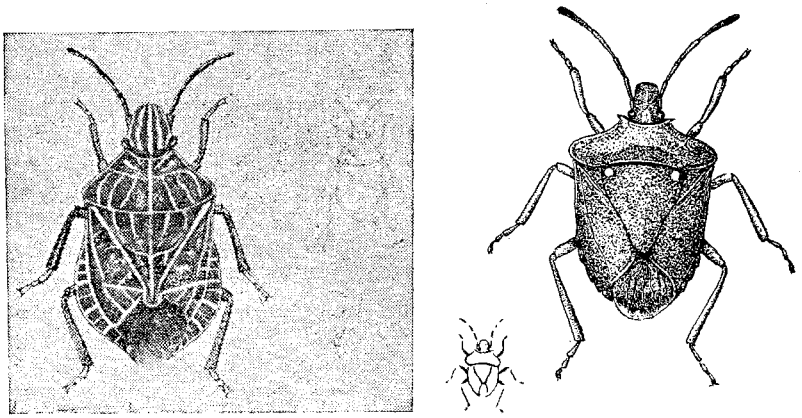
FIG. 93.—THE RICE HISPA.

(*Hispa* (*Dicladispa*) *armigera O.*)

1 *Eggs and larva on leaf tip*
3 *and* 4 *Pupa*
2 *Grub*
5 *Adult magnified*
6 *Beetles attacking Leaf*

beetles (*Aulacophora spp.*) and flea beetles like the grape flea beetle (*Sceledonta*), the bilwa (*Bael*) beetle (*Clitea*) (fig. 89) and the sunnhemp and pepper flea beetles (*Longitarsus*). Even among leaf-eating beetles there are some which are leaf miners and leaf twisters such as the mango leaf mining weevil (*Rhynchœnus mangiferæ*), the rice hispa (*Dicladispa armigera*—fig. 93) and the leaf knot weevil (*Apoderus tranquebaricus*) found on mango and country almond plants. Flowers of different kinds are attacked by blister beetles of sorts (*Epicauta, Zonabris, Lytta*, etc.—figs. 108 and 119). For these different beetles, sweeping, jarring over a sheet or use of stomach insecticides or Bordeaux mixture could be adopted according to the special nature of the crop, extent of damage and local conditions.

(7) *Plant bugs.*—This group includes sap sucking insects of different kinds such as stink bugs, mosquito bugs, lace-wing bugs, jumping bugs, spittle bugs and leaf hoppers. Stink bugs: The term stink bug is here applied to the active large and medium sized bugs which feed on cultivated plants of different kinds and most of which emit a characteristic buggy odor (fig. 94). Examples of these are the green plant bug (*Nezara viridula*) found on a variety of cultivated plants, the cabbage bug (*Bagrada cruciferarun*), the striped bug of paddy (*Tetroda histeroides*), the lab-lab bug (*Coptosoma cribraria*), the pumpkin bug (*Aspongopus janus*), the rice bug (*Leptocorisa acuta*, T., fig. 95) and the red and dusky bugs of cotton (*Dysdercus and Oxycarœnus*). These are members of the families Pentatomidæ, Coreidæ, Lygæidæ and Pyrrhocoridæ. Being large sized insects hand picking of the different stages and netting will effectively control them. Mosquito bugs: These are very active narrow bodied insects with long limbs and include some very important and serious pests of crops such as the earhead bug of cholam (*Calocoris angustatus*), the betel-vine bug (*Disphinctus politus*) and the tea mosquito (*Helopeltis antonii*). These belong to the family Miriidæ and are often difficult to control. Mechanical methods of netting, preventing them by deterrent sprays and application of strong fertilisers would help in checking such pests. Lace-wing bugs: These are very small slow moving creatures found in colonies on the tender shoots of various plants. The wings of these bugs are very delicate and arranged in patterns like lace work, hence the name. The control measures generally adopted for plant lice can be tried for these also since these attack the tender parts in the same way and cause the same kind of damage as plant lice. These are members of the family *Tingidæ* and as examples in South India we have the brinjal lace-wing (*Urentius echinus*), the plantain lace-wing (*Stephanitis typicus*) and the jasmine tingid (*Leptopharsa ayyari*, D.). Jumping bugs include what are known as Psyllids often found on plants like Indigo, mango, citrus, etc. Spittle bugs: These are active bugs of the family *Cercopidæ* the larvæ of which devlop inside frothy spittle like secretions often found on plants and mistaken by laymen for spittle. The only spittle insect



1 2

FIG. 94—STINK BUGS.

1 *Cappœa taprobanensis*, D., found on citrus.
2 *Eusarcocoris guttiger*, Th., found on cumbu, etc.

[*From S.S.I.*]

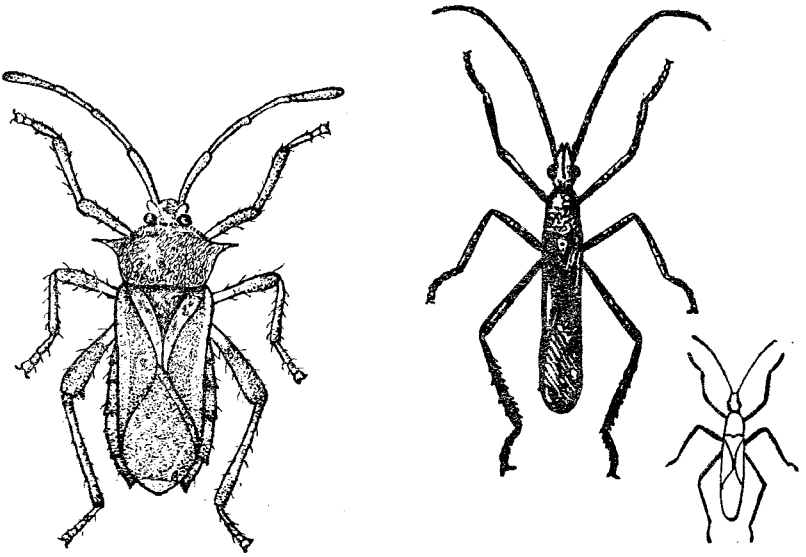


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FIG. 95—COREID BUGS.

1 *Clavigralla gibbosa*, S., found on redgrom pod.
2 *Leptocorisa acuta*, Th., the rice bug.

[*From S.S.I.*]

of any economic importance in South India is the jak spittles (*Cosmoscarta relata*, D.) noted in Coorg ; it is often found in swarms on the infested trees and the branches and shoots are found covered and wet with the frothy masses containing nymphs in different stages. Leaf hoppers—This term is applied to active jumping bugs of the two families—Fulgoridæ and Jassidæ, and these range from very minute ones to medium sized creatures ; they are generally found in large colonies and in all stages of growth. Well-known examples are the mango hopper (*Idiocerus niveosparsus*, L.) the sugarcane hopper (*Pyrilla perpusilla*, W.), the common paddy hoppers (*Nephotettix*, *Tettigoniella*, fig. 96), the cotton leaf hopper (*Empoasca devastens*, D.) and the cholam shoot bug (*Perigrinus maidis* D). Some of these hoppers often appear in large swarms and cause severe damage. Control measures against these chiefly consist in mechanical methods of netting, bagging, trapping with lights and application of contact insecticides according to the habits of the different species and the local conditions.

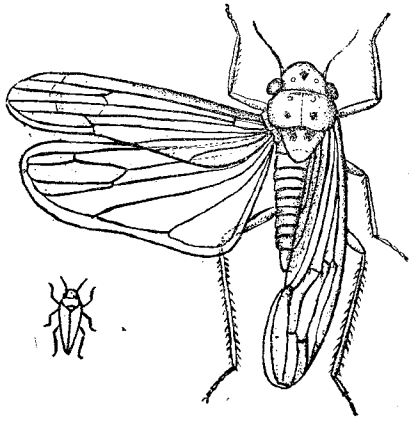


FIG. 96—A LEAF HOPPER BUG.
Tettigoniella spectra Dt., found on paddy.
[*From S.S.I.*]

(8) *Thrips*.—These insects which are members of the order Thysanoptera, are generally very small in size and some of them cause damage to plants by lacerating the tender tissue and sucking up the plant juice and in some cases causing galls also ; the nature of the damage is more or less like that caused by plant lice and mealy bugs. Though many of them are harmless, there are a few forms which are well-known crop pests ; in South India among injurious forms we have the species attacking rice *Thrips oryzæ*, the one found on onions and garlic (*T. tabaci*), the chillies thrips (*Scirtothrips dorsalis*, H.), the grape thrips (*Rhipiphorothrips*), the turmeric thrips (*Panchaetothrips*), the cacao thrips (*Selenothrips*), etc. (fig. 97). Application of contact insecticides like tobacco will be found effective against attacks of thrips.

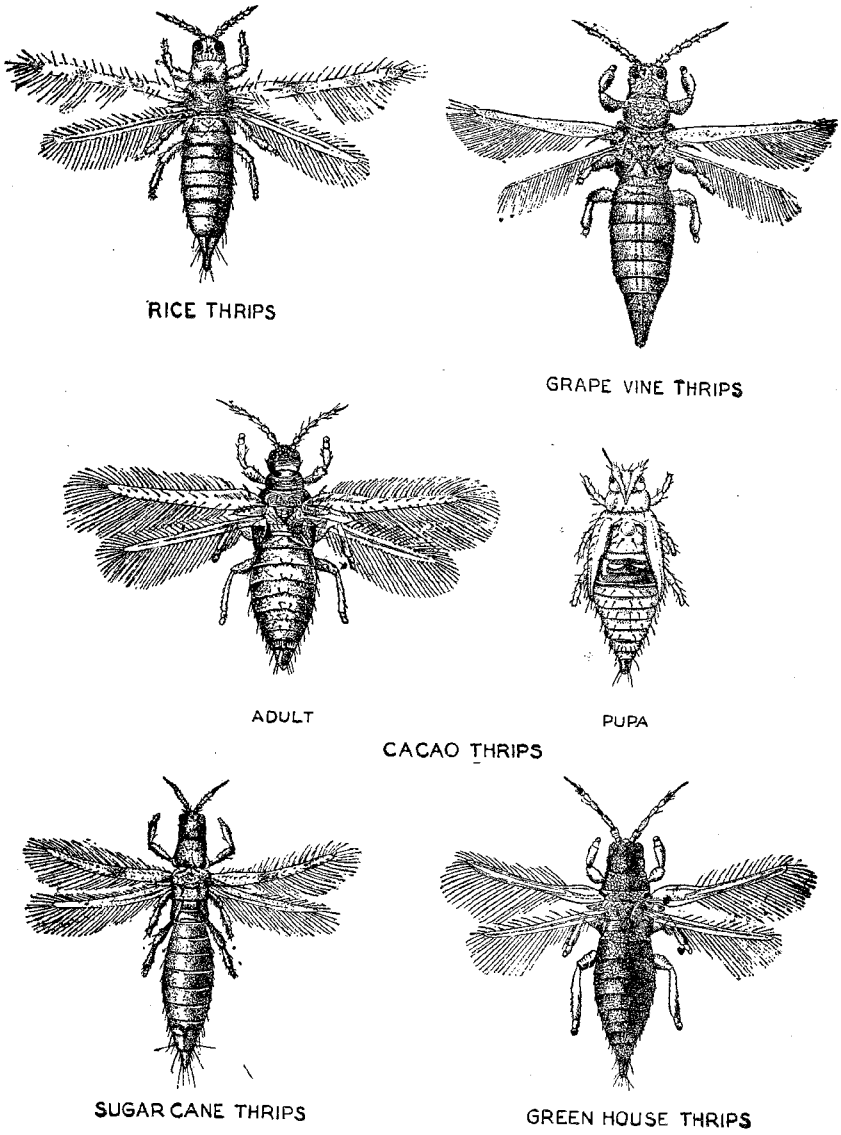


FIG. 97—SOME SOUTH INDIAN THYSANOPTERA.

1 *Thrips Oryzae* W.
2 *Rhipiphorothrips cruentatus* H.
3 *Selenothrips rubrocinctus* G.
4 *Bregmatothrips ramakrishnae* B.
5 *Heliothrips haemorrhoidalis* B.

(9) *Borers.*—Boring insects affecting plants have their representatives chiefly in the groups of Lepidoptera, Coleoptera and Diptera and with regard to the damage done to different parts of plants we find different categories which bore into root, stem, shoot, bud and fruit. The actual damage by boring is generally caused by the larva of the insect—the caterpillar in the Lepidoptera,

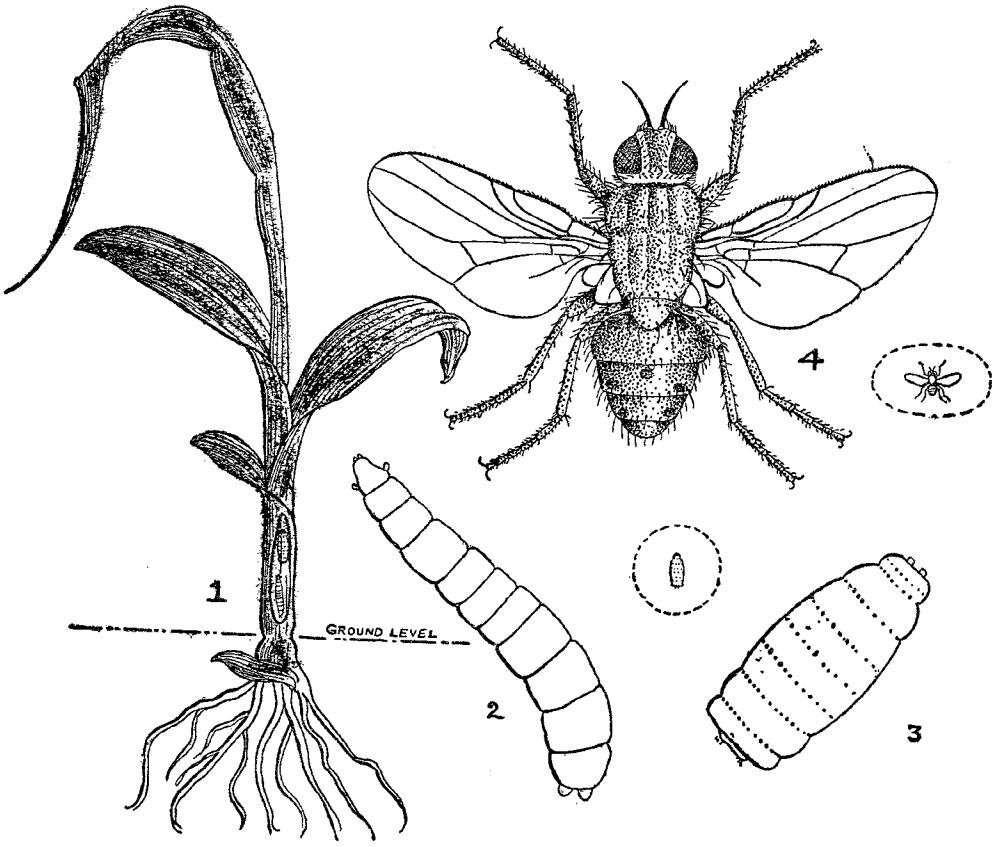


FIG. 98—THE CHOLAM FLY.

(*Atherigona indica*, M.)

1 Attacked cholam plant.

2, 3, 4 Stages—Larva, pupa and adult.

[*From S.S.I.*]

the grub in the case of beetles and the maggot in flies. In almost all these cases, the egg is laid on the surface of the plant or just below the bark, which is affected, and the larva hatching out of it burrows into the stem, shoot or fruit, grows in size and changes into the pupa often in the same burrow, and after the pupation period the adult comes out. Well-known stem and root borers are the paddy stem borer moth (*Schœnobius incertvlas* W.) the mango stem borer beetle (*Batocera rufomaculata*, D.), the citrus shoot and bark moth (*indrbela tetraonis*, M.), the cholam stem fly (*Atherigona indica*, M., fig. 98), the groundnut root borer beetle (*Sphenoptera perotetti*, G.), the bamboo and casuarina borer (*Coelosterna*), the grape stem girdler (*Sthenias grisator*, F.), and the sugarcane stem borer moth (*Chilotraea infuscatellus*, H.). Among shoot and bud borers may be mentioned the brinjal shoot caterpillar *Leucinodes orbonalis*, D.), the agathi weevil (*Alcidodes bubo*, F.), the gingelly shoot fly (*Aspondylia sesami*, F.), the cotton shoot borer moth (*Earias fabia*, S.), the jak shoot weevil (*Ochyromera artocarpi*, M.), the cotton budworm (*Phycita infusella*, M.), the redgram bud weevil (*Ceuthorhynchus asperulus*, F.), and the brinjal budworm (*Phthorimœa blapsigona*, M.). Borers of fruit include the well-known cotton pink bollworm (*Platyedra gossypiella*, S.), the mango nut weevil (*Cryptorhynchus mangifera*, F.), the pomegranate butterfly *Virachola*, fig. 99) and the fruit flies of cucurbits, mango, guava, etc. (*Chaetodacus spp.*).

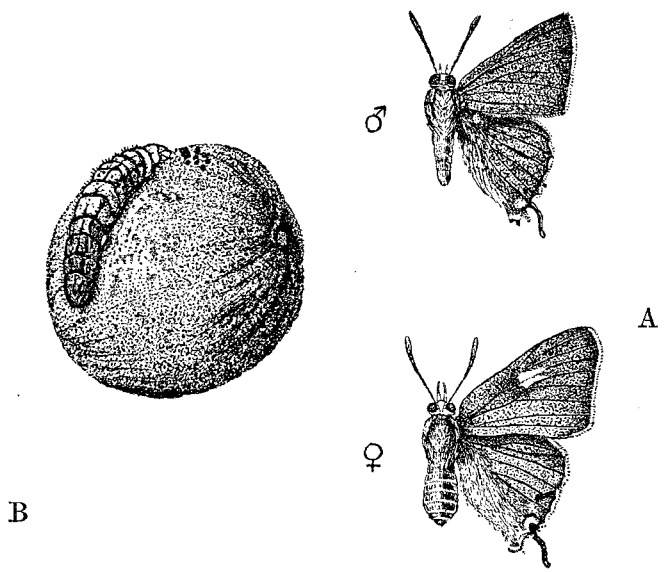


FIG. 99—THE POMEGRANATE BUTTERFLY.
(*Virachola isocrates, F.*)
A. Male and female butterfly
B. Larva on fruit.
[*After hefroy*]

In the following arrangement an attempt is made to give the reader a general idea of the various categories of insects which attack the different parts of growing plants as they grow :—

Different parts of plants. (1)	Chief categories of insects. (2)	Some South Indian examples. (3)
Sown seeds and roots underground.	White grubs, crickets, termites, root bugs, root beetles, wire worms and ants.	Rose and other chafer grubs, mole cricket, sugarcane and grape termites, tobacco root bug, the ragi root aphis, potato and tobacco root beetles, aphid carrying ants, wooly blight of apples, etc.
Young plants above ground surface.	Cutworms, surface grasshoppers and beetles, flea beetles, ants, crickets.	Cutworms on various crops like potato, paddy, tobacco, the brown ground grasshoppers (Chrotogonus) on various cereals and other dry garden crops, the surface weevil of cotton, small red and nibbling brinjal seedlings and plant lice on various garden seedlings.
Bark and stem.	Bark caterpillars, bark grasshoppers, bark bugs, stem boring caterpillars and grubs stem maggots, stem girdlers, scale insects, termites.	Bark borer of avenue and fruit trees, the mango stem borers, the borers in stems of paddy, millets, agathi, etc., cotton stem weevil, the grape vine girdler, cowpea stem fly, silver shoot fly, red palm weevil, sweet potato weevil, the nim scale, cane mealy bug, the rubber bark beetles.
Shoots, leaves and flowers.	Grasshoppers, leaf cutter bees, beetles of various kinds (chafers, tortoise beetles, weevils, leaf miner beetles), caterpillars of numerous categories (hairy spiny, smooth, sluggish, leaf folding, leaf mining, shoot and leaf webbing, bag building), sawfly grubs, gall fly maggots, leaf and shoot bugs of different habits [stink bugs, hopper bugs, spittle bugs, plant lice, scales and mealy bugs, mealy wing', Psyllidae (jumping bugs), mosquito bugs (Capsidae), lace bugs, etc.], thrips, blister beetles.	The rice grasshopper, the Deccan grasshopper, the rose leaf cutter bees (Megachile), rhinoceros beetle, the chafers on grape leaves, pumpkin beetles, rice hispa, flea beetles on grape. radish, millets, sunnhemp, etc., blister beetles on millets, etc., caterpillars on various crops— red hairy caterpiliar, lab-lab sphinx, cotton leaf roller, mustard sawfly, mango hopper , betelvine bug, grape, chillies and onion thrips, coffee green scale, cane mealy wing, cane leaf hopper, cotton aphis, brinjal lace wing bug, etc.
Fruits, earheads, seed pods.	Fruit pod and earhead caterpillars, fruit moths, sucking bugs, fruit flies, earhead and pod bugs, pod flies, earhead bugs.	Mango and other fruit flies, bollworms of cotton, citrus fruit sucking moths and bugs, red gram pod fly, tobacco seed capsule and tomato borer, pulse bruchids, pepper pollu flea beetle, the pomegranate butterfly, potato borer, castor-seed borer, brinjal fruit borer, etc.

Among the various categories of insect pests affecting plants the borers are the most serious and at the same time difficult to control effectively. Prophylactic measures are the most effective in all cases of borer attack since insecticides will be of no avail against these internal feeders. Preventive and other measures against them include the pruning and the destruction of first-attacked parts, tackling the borers in tree stems by mechanical devices and insecticides, the maintenance of general field and plant sanitation and the utilization of natural enemies wherever possible.

In the following chapters which are mainly devoted to the consideration of the important crop pests of South India, it is intended to briefly deal with the main features of these insects under groups of crops such as cereals, sugarcane, pulses, oil-seeds, vegetables, fruits, palms, garden plants, etc. The information attempted to be given in connexion with each insect or groups of insects is mainly intended to help the South Indian farmer to get some ideas of the more important features of the different forms referred to easily recognize them, note correctly the nature of the damage each causes to the plant, get some information on its life history and habits and to adopt timely and suitable measures of control from the suggestions given under. No hard and fast rules have been adhered to in the treatment of the different insects; as far as possible, the pests of each crop are dealt with in the order of their recognized importance. In the case of each insect only the important points are touched upon since it will not be possible to give all the details of every pest in a handbook like this.

Some of the important papers dealing specially with South Indian Economic Entomology are added in Appendix E (Bibliography) and readers might refer in this work.

CHAPTER XI.

Insect Pests of Paddy

From time immemorial rice (paddy) has been the most important cultivated plant in South India. As the staple crop of the population, it is now grown on an area of over thirteen million acres in this province, and it is practically the only important crop in some of the delta tracts of the Northern Circars and the Tamil districts. Though we possess no regular statistical records to gauge the extent of damage caused in various ways to this important crop or the consequent loss sustained by the paddy cultivator, it is well known that insects of different kinds levy a heavy toll on the paddy plant year after year, and that in some years such a loss in some tracts has been very considerable.

Of about three dozen insects noted below as affecting paddy in South India, only about a third of that number can be considered to be important or major pest, which appear almost regularly every season and cause the greater portion of the damage to the plant; of the rest, some are occasionally found harmful, while others appear now and then only as sporadic pests during certain years. These latter may be called pests of minor importance. The insects noted in the paddy pests calendar referred to before may be regarded as some of the major pests of paddy in South India (*see* Frontispiece). The others are usually of minor importance though occasionally some of them become sporadic and assume pest proportions. As regards the control of paddy pests in general, it is found that though most of them cause visible and appreciable damage to the crop only during the growing period in the field, some of these insects have their beginnings even in the nurseries themselves; but they are generally overlooked and thereby allowed to multiply and carry on their increased activities in the transplanted fields. It is only when the damage has become fairly serious and appreciable that the farmer generally takes notice of the matter and worries himself, in many cases when it is even too late to save the crop. It need hardly be added that it is always easier to control a pest in the seed-beds and nurseries than in the transplanted areas; some care in eliminating pests and diseases at the time of transplantation will go a great way in reducing the degree of pests infestation in the fields. As far as we have seen, preventive measures and cultural and mechanical methods have been found to prove more effective and far more economic than other measures with most of the paddy pests. In the case of this crop it has also to be observed that in some tracts of the province, where conditions are favourable one crop of paddy follows another—paddy after paddy—monotonously in three successive crops year after year, and thus not only is the evil of a one crop rotation permanently established, but such a state of affairs, when there is paddy all through the year, also

helps insect pests of sorts to gain easy facilities to breed continuously without any break and thereby become a constant source of trouble. With such an extensively and often continuously grown crop like paddy, the need for co-operation between neighbouring farmers of any area in the matter of pest control is far more essential than in the case of other crops.

THE SWARMING CATERPILLAR (*Fig.* 100)—(*Spodoptera mauritia*, B).—The adult insect is a stout-built dark-brown moth which is not generally found in the fields. The swarming caterpillar is the larva of caterpillar of this moth. This insect has a wide distribution occurring throughout the Oriental and Australian regions, and in South India, it is found in all rice areas, especially along the West Coast and the delta tracts of the Northern Circars.

Life history and habits.—The mother moth lays small spherical eggs in batches on various kinds of wild grasses and paddy and covers them with greyish hairs; there may be two or three hundred in each batch. The young caterpillar that hatches out is green and escapes our notice, especially in the nurseries. Feeding on the green foliage it grows in size and in about twenty days it is full grown measuring about an inch and a half in length. It is smooth and cylindrical and when full grown has a dark to pale green colour with dull dorsal and sub-dorsal stripes. There is found a great deal of variation in the colour. The full grown caterpillar enters the soil and changes into the pupa in an earthen cocoon; the pupa is dark-brown about $\frac{1}{2}''$ long with two very slender spines at its narrow apex. In from ten to fifteen days the moth emerges from the pupa and in a day or two it mates with the male and is ready for egg laying. The life cycle is completed in seperate from 30-40 days. The caterpillar often appears suddenly in swarms of thousands, completely eats up a whole field and move to another; this is why it is also called the "army worm." The caterpillars feed by night and hide during the day. It is found to breed on different kinds of grasses also. Both wasp and fly parasites attack this creature and occasionally act as efficient natural checks *

Control measures.—Infested nurseries and small plots may be flooded if water is available; this will bring up the hiding caterpillars and birds will easily destroy them. A herd of ducks will destroy the caterpillars if let into the area and insectivorous birds can be given perches in the fields and field bunds. In any mass infestation, small plots can also be isolated and the progress of the caterpillar prevented by digging a trench around the infested field wherever possible. The mechanical method of sweeping the caterpillars by brooms into baskets or sweeping them into handnets and killing them is also effective if done thoroughly. When caterpillars are found parasitized in numbers, the collected caterpillars may be kept in cages and the hatching parasites liberated in the fields.

* Besides the flies noted at foot of page 106 an ichneumon (*Charops*), two braconids (*Chelonus* and *Apanteles*) and a Chalcid (*Euplectrus*) have been noted as parasites in South India.

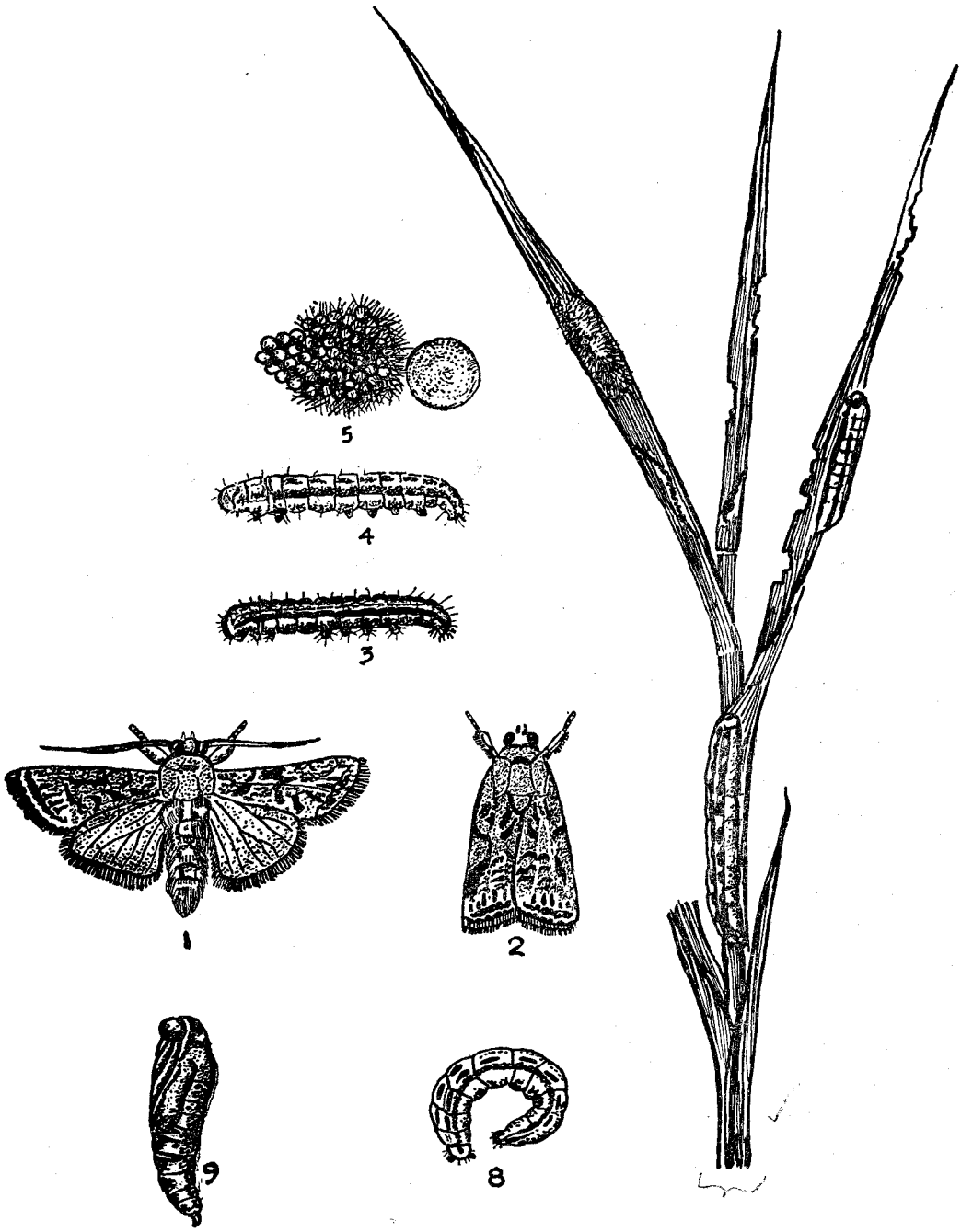


FIG. 100.—THE PADDY SWARMING CATERPILLAR.

(*Spodoptera mauritia*, B)

Plant infestation and stages. 1 and 2 Moth. 3, 4, 6, 8 Caterpillars, 5 and 7, Eggs. 9 Pupa.

Calcium arsenate dusting will also be found effective in checking the pest; but this method may not, however, be possible in extensive areas and in rainy weather. Recent trials have shown that B.H.C. 5% has been effective in controlling the pest. Since the insect is found on various grasses also besides paddy, attention may be paid to these alternate food plants before the pest affects growing paddy. Any of these methods to be effective should be adopted without any delay, since the pest is of such a nature that in a single night a swarm might destroy a wide expanse of paddy fields.

THE PADDY STEM BORER. (*Fig.* 101-[1-4])—*Schœnobius incertulas* W.)—This pest is also the caterpillar of a moth; it is found in almost all tropical and sub-tropical regions where paddy is grown. Unlike the army worm this caterpillar is a borer feeding from inside the stem of the paddy plant, and the external symptom of the presence of the pest consists in the gradual fading and death of the whole central shoot in a young plant and the whole earhead in a mature one; and if the stem is split open the caterpillar, its pupa or the signs of its work can be noted. In South India it is particularly common in the Northern Circars, Ceded Districts Ramanathapuram, Tanjore and Malabar.

Life history and habits.—Eggs are laid by the female moth in small masses on the tender leaves and, as in the army worm, the mass is covered by a layer of buff hairs. The young caterpillar which hatches out crawls along the leaf or hangs down by a silken string and reaches the stem where it bites a hole near a node and enters the stem; inside the stem it grows feeding on the inner tissue. When full-fed, the caterpillar has a pale yellowish white colour, is smooth and about an inch in length. It pupates inside the stem itself, often lower than the stem, within a transparent silken cocoon and after the pupation period, emerges as a moth through a hole previously made by the caterpillar in the stem. The female moth is bigger than the male and has bright yellowish upper wings with a minute but distinct black dot on each of them. The male is of a pale whitish yellow colour and the spots on the forewings are not conspicuous. No other plant on which this insect breeds has been discovered so far. There are a few natural enemies affecting the eggs and the caterpillar* but these are not always effective as control agents.

Control measures.—Being a borer, preventive measures are found more successful in the case of this insect. The presence of the pest should be made out in the nurseries. Egg masses can be collected and destroyed. While transplanting, seedlings showing dead-hearts can be eliminated. The female moth is very commonly attracted to lights, and the light trap as a control measure against

* Two ichneumonids *Amaurocmorpha schoenobii.* V., *Ischnojoppa luteolater.* F.) a medium sized yellowish braconid (*Tropobracon indica* R.) and the Chalcid wasps *Tetrasichus schoenobii* and *Trichogramma indicum* have been found as parasites in South India.

FIG. 101.—INSECTS ON RIPENING PADDY.

1 to 4 The paddy stem borer (*Schoenobius*).
5 to 9 The rice bug (*Leptocorisa*)
10 to 11 Blister beetles (*Epicauta, Lytta*).
12 to 13 The climbing cut worm (*Cirphis* sp.).

this insect has shown very good results. By top clipping the seedlings before transplanting the egg masses which escape our notice will also be removed. Once the borer attacks a seedling or grown up plant nothing can be done to save it. In localities where it is possible, the stubble after harvest may be ploughed up and destroyed, since the pest lingers as larva or pupa in these stubbles long after harvest and then passes on to the next crop of paddy.

THE RICE HISPA (*Figs.* 93 *and* 102)—[*Dicladispa* (*Hispa*) *armigera*, Ol.].—This small bluish black beetle fringed with numerous short spines on its body is found all over India and as a pest it occurs in the West Coast, Salem, along the Coromandel Coast, in North Arcot and in the Northern Circars. Third crop paddy in South Kanara suffers from this pest very seriously in certain years. It attacks the younger stages of the paddy plant and generally disappears when the plants mature and the earheads are out. The damage consists in the beetle eating up the green matter of the leaves and this causes them to fade and wither. The presence of characteristic parallel white lines on the leaf surface is an indication of attack by this beetle. When the insect appears in numbers in the nurseries and the planted fields, the damage is often serious.

Life history and habits.—All the stages of the insect are passed on the paddy plant itself. The eggs are laid into the tissue of the young leaf close to the tip; the grub which hatches out burrows into the leaf tissue feeding on the green matter; this produces the characteristic blister patches on infested leaf tips (*see* fig. 93). The pupa is found in the same burrow and after the pupation period it emerges as adult. Two or three generations are passed through in one paddy season.

Control measures.—This is an insect which can be effectively checked if noted in time and proper action taken. In nurseries the beetles can be collected in numbers with a handnet; if water is available, the seedings can also be flooded when the beetles will float up and these can be swept together and destroyed. The leaf tips of seedlings may be clipped before transplantation and the clippings which contain the younger stages destroyed. In valuable experimental plots spraying or dusting with stomach insecticides will also be found effective. B.H.C. 5 % dust is reported to have given very convincing results in Bengal.

THE RICE BUG (*Figs.* 95 *and* 101)—(*Leptocorisa acuta*, T.).—This active greenish yellow insect with the characteristic buggy odor and long limbs chiefly found along the west coast, though it is occasionally reported from Ganjam, Tinnevelly and Coimbatore. It appears at a stage when the plants have flower and the grains are in the milky stage. Both the adult and the young bugs are active and damage the plant by sucking up the juice from the milky grains which become chaff in consequence. In this way in a badly infested field the earheads show numerous grains sucked up empty and turned brown and dry; on some of the plants the bugs

will also be in evidence. When the stem borer caterpillar attacks paddy in the later stages such plants also show white earheads but the difference between the two is that, when it is the rice bug, only some grains (and not all) are found chaffy where as stem borer attacked ears are completely dry including the stalk. Generally the bug disappears when the earheads begin to ripen and the grains become hard.

Life history and habits.—The mother bug lays brownish seed like eggs in rows of 10 to 20 on the leaf blade: in a week each egg hatches into an active slender greenish nymph which feeds by sucking the plant sap from the tender shoots and leaves (fig. 101); in about a fortnight the nymph assumes the winged adult stage when it is able to fly about and move from plant to plant and feed on the milky ears. In the West Coast the pest breeds freely during the monsoon months and causes considerable damage to paddy. The insect also feeds on different grasses besides paddy.

Control measures.—In areas where the pest usually occurs the field bunds should be kept clean and properly weeded as a preventive measure; all grasses on which the pest will otherwise breed should be destroyed before paddy comes up. When however, a field is badly infested, the most feasible and economical method is the mechanical one of collecting bugs in handnets or bags and destroying them. The use of the handnet will be found very efficient; if systematic sweeping is done with a net or bag for two or three mornings, the pest can be reduced considerably; this method is commonly adopted in Malabar. Clean cultivation followed by the prompt use of the handnet has been found to control the pest sufficiently well. Dusting with B.H.C. 5 % has been found to exterminate the pest. A tiger beetle * sometimes feeds on this insect.

THE RICE GRASSHOPPER (*Fig.* 102)—(*Hieroglyphus banian*, F.).—This medium sized green insect is the chief grasshopper pest of paddy in South India and is found in almost all paddy areas though it is specially bad in the West Coast along the Ghats and in the Ganjam and Vizagapatnam districts. This is a well-known pest of paddy and both the young and adult insects often cause very serious damage to the crop in certain years. It is found on cane also sometimes in parts of the N. Circars.

Life history and habits.—Eggs are laid by the female grasshopper in masses of over 30 to 40 under the soil, especially along the sides of field bunds during the months from October to December; these egg masses remain under the soil for several months and hatch into young grasshoppers soon after the first rains in the following June-July period. Though these are active they are wingless (fig. 102) and grow by feeding on the grasses, etc., on the

* Cicindela sexpunctata.

FIG. 102.—INSECTS ON GROWING PADDY.

1 to 3. The rice grasshopper (*Hieroglyphus*).
4 to 6 The rice case worm (*Nymphula*).
7 to 9 The horned caterpillar (*Melanitis*)
10 to 13 The swarming caterpillar (*Spodoptera*).
14 to 16 Rice hispa (*Hispa*).
17 to 19 The rice skipper (*Pelopidas*)

field bunds until the paddy comes up, by which time the young hoppers become winged adults and begin to damage growing paddy by feeding on the leaves and shoots and cutting off of the earheads.

Control measures.—Bagging and netting during the earlier stages of the pest when the hoppers are found on the field bunds have been found effective. The driving of the half-grown and adult hoppers to a field corner and beating them to death with sticks and palmyra leaves is a common and effective method in vogue in South Malabar. Destroying the egg masses by scrapping the bunds and ploughing up the field during the early summer months, wherever possible, has also produced good results by egg destruction in some tracts like Ganjam and South Malabar. Dusting with BHC 5% has given spectacular results.

THE RICE CASE-WORM. (*Fig* 102.)—(*Nymphula depunctalis*, Gr.).—This insect is also a moth, the larva of which is found on young paddy and usually in fields under swampy conditions. The slender greenish caterpillars which measure over ½' when full grown cut the paddy blades into short lengths, construct tubular cases, remain inside these small rolls (see figure) and feed on the foliage. It is semi-aquatic in habits and is able to breathe under water. In a badly infested field numbers of these leaf cases could be seen attached to the plants, and the foliage eaten up.

Life history and habits.—The tiny eggs are laid on the tender leaves and the larva that hatches makes the leaf fold and remaining inside it grows by feeding on the foliage; pupation takes place inside the larval case. The moth that comes out is a small delicate creature with the wings white and speckled with pale brown markings.

Control measures.—The best method is to dislodge these larval cases and destroy them. This is usually done by disturbing the plants by passing ropes or thorny branches of trees over them and the water in the field drained off. The addition of a little kerosene to the water in the field before shaking the plants will help in killing the caterpillars in the cases which drop into the water.

THE PADDY GALL-FLY (*Fig* 103)—(*Pachydiplosis oryzæ W.*).—This is a fly pest and the damage to paddy which is caused by its larva is popularly known as "Silver shoots" and in the vernacular *Anaikombu* (Tamil) and *Kodu* (Telugu). The fly is a delicate mosquito-like insect with long legs. This is found chiefly in the Northern Circars, Tanjore, Ramnad and South Kanara districts. The external symptom of the work of the pest is the formation of pale white or bluish hollow outgrowths from the paddy stems preventing formation of earheads. This abnormal

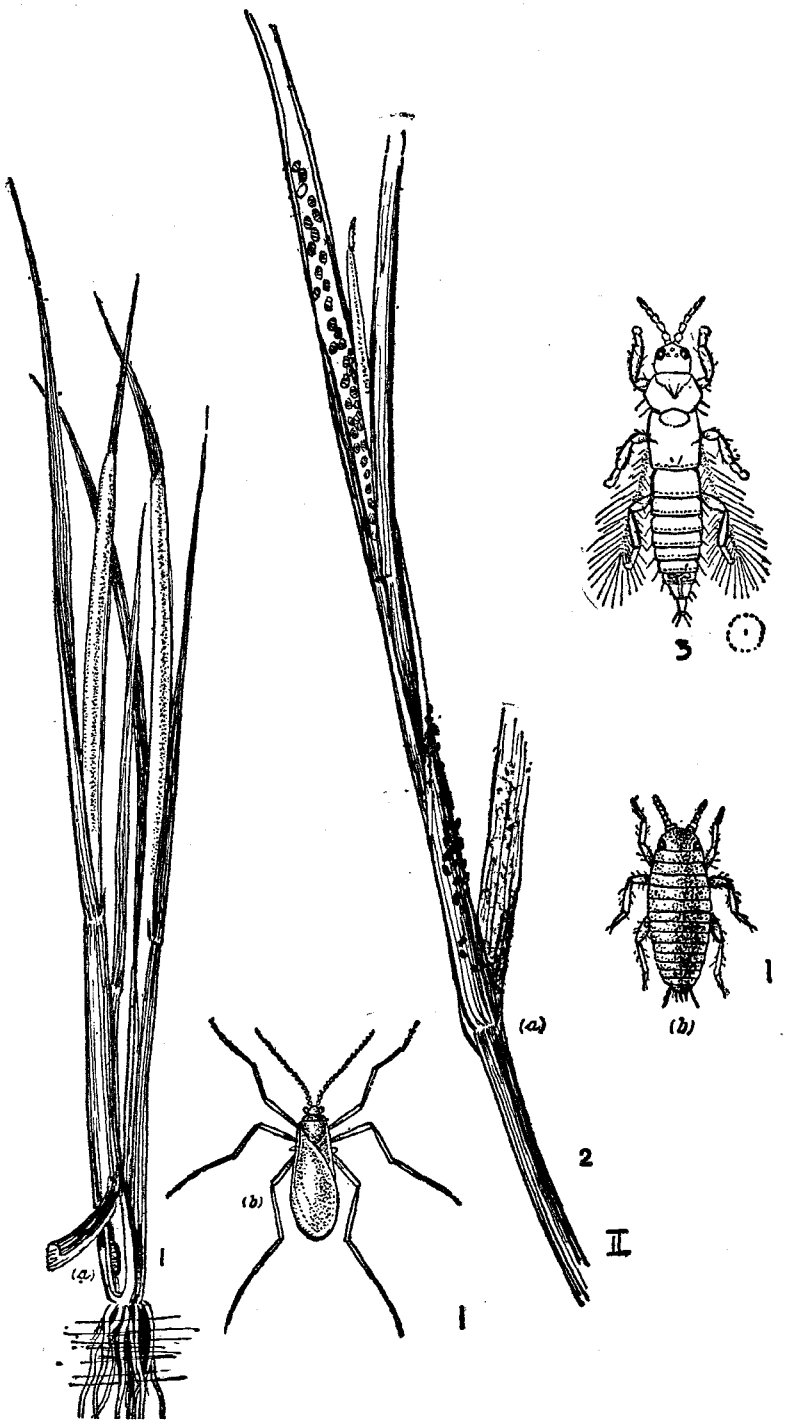


FIG. 103. THE PADDY GALL FLY, MEALY BUG AND THRIPS

1 (*a*) & (*b*) The gall fly (*Pachydiplosis*) grub in plant and fly.
2 (*a*) & (*b*) The mealy bug (*Ripersia*) on plant and adult female.
3 Thrips (*Thrips oryzæ*).

growth of the plant is the result of the irritation caused by the fly maggot inside the stem. This is occasionally serious in the Northern Circars.

Life history and habits.—The parent fly deposits eggs on the tender shoots; these eggs hatch out into slender footless maggots and the latter burrow into the shoots and cause irritation, and as a result, the long hollow characteristic galls or "Silver shoots" are formed. The pupa which is found inside these hollow outgrowths emerges as the fly after the pupation period. Very often the fly maggots are found heavily parasitised by minute wasps. The insect has also been noted to breed on a few wild grasses.

Control measures.—Being an internal feeder and since the damage it causes becomes visible only after the gall is produced and the plant shoot damaged, only preventive measures will be of any avail against this pest. Grasses on which the insects breed may be removed from bunds to prevent the pest multiplying on them when there is no paddy. The adult insect comes to lights and as such, light traps may be put up sufficiently before the period when the pest is expected.

THE PADDY MEALY BUG (*Fig.* 103)—(*Ripersia oryzæ* Gr.).—This insect is the cause of the "Soorai" disease of paddy in the Tanjore delta, South Arcot, Trichinopoly, Salem and parts of Coimbatore; recently it has also been found in parts of the N. Circars and Malabar. It is a reddish white soft mealy bug found in colonies attached to the paddy stem covered over by the outer sheathing leaves. It hardly moves about. The damage is caused by hundreds of these bugs attaching themselves to the succulent stem and sucking up the plant sap; this drainage affects the growth and makes the plants stunted and sickly; in many cases no earheads are put out. An infested field shows isolated patches of stunted and sickly looking plants. When the outer sheath of an infested stem is drawn apart, numerous bugs are seen attached to the stem in all stages.

Life history and habits.—Numerous eggs are laid on the stem by the mother bug. The pale yellowish white young ones are active and crawl about the plant for a while and settle themselves on the plant stem and grow by feeding on the sap. The young and the adult have the same feeding habits and the adult females are generally stationary and wingless. Sometimes colonies of these insects are found subject to the attacks of natural enemies like lady-bird beetles and parasitic flies and wasps.

Control measures.—The pest is rather difficult to check if not controlled in the early stages by attending to the early attacked plants, and in the nurseries before transplantation. Different methods of control have been tried against this insect but so far the results have not been so satisfactory as one would have wished;

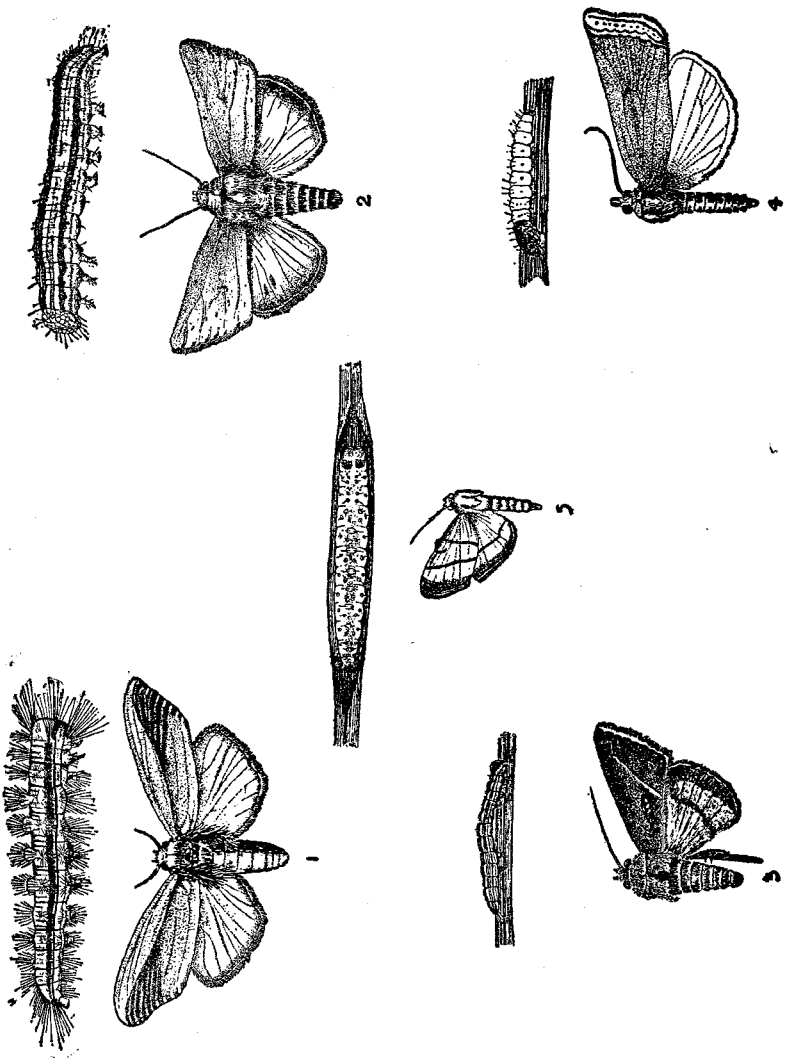


FIG. 104.—SOME CATERPILLAR PESTS OF PADDY

1. The yellow hairy caterpillar (*Psalis*) and moth.
2. The climbing cut worm (*Cirphis*) and moth.
3. The semilooper worm (*Mocis*) and moth.
4. The root stemborer (*Ancylolomia*) and moth.
5. The leaf roller (*Cnaphalocrocis*) and moth.

it appears to be a difficult one to deal with. As in the gall fly, the multiplication of the pest can be considerably reduced by dealing with the various grasses on which this mealy bug is found to breed as alternate food plants.

THE RICE THRIPS (*Figs.* 97 *and* 103)—(*Thrips oryzæ*, W.).—This is a minute insect found in numbers in very young paddy often when the expected rains are not received. It has been noted chiefly in Malabar, Chingleput, Mysore and Coimbatore. The insects are small active creatures found in all stages inside the rolled up tips of the tender leaves; they lacerate the parts and suck up the plant sap and this causes rolling up and fading away of the leaf tips; and in the case of very young seedlings, the leaves wither and the young plant suffers much. The adult insects are the small creatures having fringed wings.

Life history and habits.—The life history of the paddy thrips is more or less similar to bugs; eggs are laid in the tender leaves and the active young ones that hatch out feed exactly like the parent, and in course of time assume the adult winged condition.

Control measures.—During certain unfavourable seasons *Thrips* cause appreciable damage to nurseries and transplanted seedlings. A smart shower of rain is sufficient to remove thrips. In its absence the fields may be flooded with water wherever available. In valuable plots and nurseries the pest may be checked by spraying water mixed with some tobacco decoction or B.H.C.

THE PADDY LEAF ROLLER (*Fig.* 104)—(*Cnaphalocrocis medinalis*, G.).—During certain seasons young paddy suffers to some extent from the attacks of this caterpillar which rolls up the leaf tips and feeds from inside the roll.

It has been noted in pest form chiefly in Ganjam, Malabar and a few other places.

Life history and habits.—The adult insect is a small moth with yellowish brown wings; the caterpillar is green and a little over half an inch in length before pupation. The pupa is found inside the leaf fold itself.

Control measures.—The early clipping off of the infested tips and their destruction will check the multiplication of the insect.

THE CLIMBING CUTWORM (*Fig.* 104)—(*Cirphis albistigma*, M.).—This insect is in general features and habits very much similar to the swarming caterpillar (*Spodoptera*) and both belong to the same group. The climbing cut-worm does not, however, occur regularly as a pest as does the swarming caterpillar. It appears as serious only during certain years chiefly in the Coromandel tracts on grown up paddy during January-February in such years when the tract gets heavy rainfall and the fields are flooded.

Life history and habits.—Life history is similar to that of the army worm and the adult is a stout dark brown moth. The caterpillars which are smooth, cylindrical and stout appear in swarms, climb the plant and cut off the earheads. One or two species of *Cirphis* with same habits have also been noted occasionally with this pest, viz., *Cirphis loreyi* and *C. unipuncta.*

Control measures.—The pest is rather difficult to deal with. Birds are found to do some beneficial work in such infestations by feeding on these larvæ; these may be helped with perches in the field.

The Striped Bug (*Fig.* 111-4)—(*Tetroda histeroides*, F.).—This dark brown plant bug is bigger and stouter than the rice bug (*Leptocorisa*) and can be easily recognized by the V-shaped whitish mark on its dorsal surface (*Nama vandu* in Tamil). It settles in numbers on young plants in patches and sucks up the sap from the tender parts. Infested fields present a yellowish brown, dry appearance. This has been noted as a pest of some importance only in parts of Tiruchirappalli till now.

Life history and habits.—The cylindrical eggs are laid along the lower surface of the leaves in batches of four or more in two rows. These hatch within a week and the young nymphs grow by feeding on the plants like the parents. In about 40–50 days they reach maturity.

Control measures.—Hand picking and sweeping with nets will be found very effective in the early stages; the spraying of an insecticide like crude-oil emulsion or fish-oil soap as a deterrent was found effective on one occasion. B.H.C. 5 per cent dust has given effective control. Ducks let into the affected fields voraciously devour the bugs.

The Spotted Jassid of Paddy (*Nephotettix bipunctatus*, Fabr.)—This is an active little bug, green in colour with two minute conspicuous black spots on the males. The insect which is generally considered to be only of minor importance suddenly flares up to prominence during certain years attacking young transplanted paddy especially under well irrigation. The hoppers occur in their millions, suck up the plant sap and cause withering of the plants. In cases of severe attack the growth gets stunted and the plants wither away ultimately.

Life history.—The female lays here small cylindrical eggs on the underside of the leaves and the individual capacity is 24 to 34. The nymphs hatch out in about four days and begin to feed on the plant sap. They attain the adult stage in about 20 days moulting five times. They breed on some of the common grasses during the off-season.

Control measures.—Sweeping with handnets and destroying the adults in kerosenated water as well as the use of the light trap may bring about a certain amount of reduction in the population during the earlier stages. But neither of these methods give any appreciable relief when the pest multiplies beyond control. Spraying with D.D.T. at 0·1 per cent has been found to give spectacular results since the entire population was found to die in the course of three days. The quantity of the chemical required for an acre is 2 lb. costing about Rs. 6.

The following insects are also found occasionally feeding on paddy in different parts of the province, but they are minor and appear in pest form very rarely :—

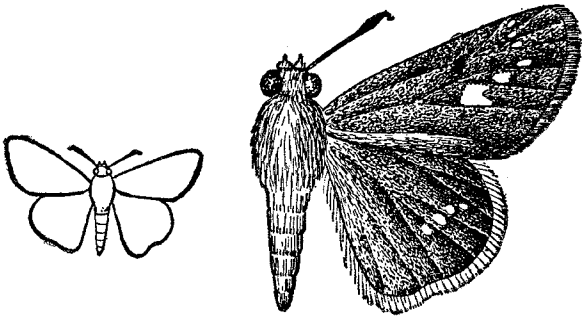


FIG. 105.—A SKIPPER BUTTERFLY SOMETIMES FOUND ON PADDY. [*Pelopidas* (*Parnara*) *colaca*, M.]

(*From S.S.I.*)

MINOR LEAF CATERPILLARS—*The paddy skipper* [*Pelopidas* (*Parnara*) *mathias*, F.] (FIG. 102).—A smooth green caterpillar with a distinct head. The adult is a dark brown skipper butterfly found all over South India; another (*P. colaca*, M. fig. 105) is also noted sometimes. *The horned caterpillar of rice* (*Melanitis ismene*, C.) (Fig. 102–7).—This elongated green caterpillar with a rough body surface has two red horn-like processes on the head and pupates on the leaf. The adult is a dark brown butterfly with large wings. It is found all over the province. *The yellow hairy caterpillar* (*Psalis pennatula*, Hb. 1) (Fig. 104–1).—An yellow brown hairy larva about 1½ inches long found often on grasses and sometimes on paddy. Pupa found inside a pale white cocoon of silk and frass attached to the leaf. The moth is a stout one with straw coloured upper wings. Has a very wide distribution. *The paddy semilooper* (*Mocis frugalis*, Fb.) (Fig. 104–3).—An elongated smooth greyish yellow semilooper caterpillar; pupates in a cocoon among leaves. The adult is a grey brown moth with pale striæ on wings. *The hairy caterpillar* (*Nisaga simplex*, W) is occasionally noted in the North Circars. The noctuid caterpillar (*Borolia venalba*, M) is another minor pest. *The earhead webber* (*Pityocona xeropis* M) is a small caterpillar occasionally found webbing paddy earheads in Coimbatore. The noctuid caterpillar, (*Leucania inferens*, W) has been noted to attack young paddy seedlings in parts of Mysore.

MINOR LEAF BEETLES—*The paddy Leptispa* (*Leptispa pygmaea*. B.) (*Fia*. 106).—This is a small elongated smooth bluish beetle often found in company with rice hispa, chiefly in different parts of Malabar. The occasional damage done to paddy by this creature and the life hisotry are more or less similar to those of rice hispa.

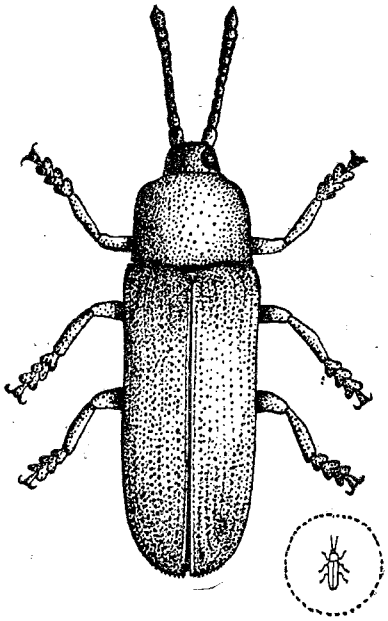


FIG. 106.—THE PADDY LEPTISPA.
(*Leptispa pygmæa* B.)

The spotted leaf beetle (*Oides affinis*, J.) (*Fig*. 107–5).—An ovoid reddish brown beetle with a large dark blotch on each upper wing. Found often in numbers but doing hardly any damage. Noted in Malabar.

The leaf weevil (*Athesapeuta oryzae*, M.) (*Fig*. 107–2).—A small dark grey weevil; at times found in paddy fields in Coimbatore, status as a pest very doubtful.

The gregarious blue beetle (*Haltica cyanea*, Web.) (*Fig*. 107–3).—A medium sized steel blue beetle bigger than "*Leptispa*" and often found in hundreds on the paddy plant; this is often mistaken as a serious pest of paddy because it is found in numbers on paddy plants; but it is harmless and is found breeding not on paddy, but on the common weed *Ammania* found along field bunds.

Flower feeding blister beetles (*Psalydolytta*, *Epicauta* and *Lytta*) (*Fig*. 108).—These blister beetles occasionally visit the paddy plant during the flowering period and feed on the pollen; they are, however, very rarely serious. A red headed dark blister beetle

(*Epicauta*) (Fig. 108) is often found as a sporadic post of many crops including paddy in the submontane villages of the South Kanara district during July-November season.

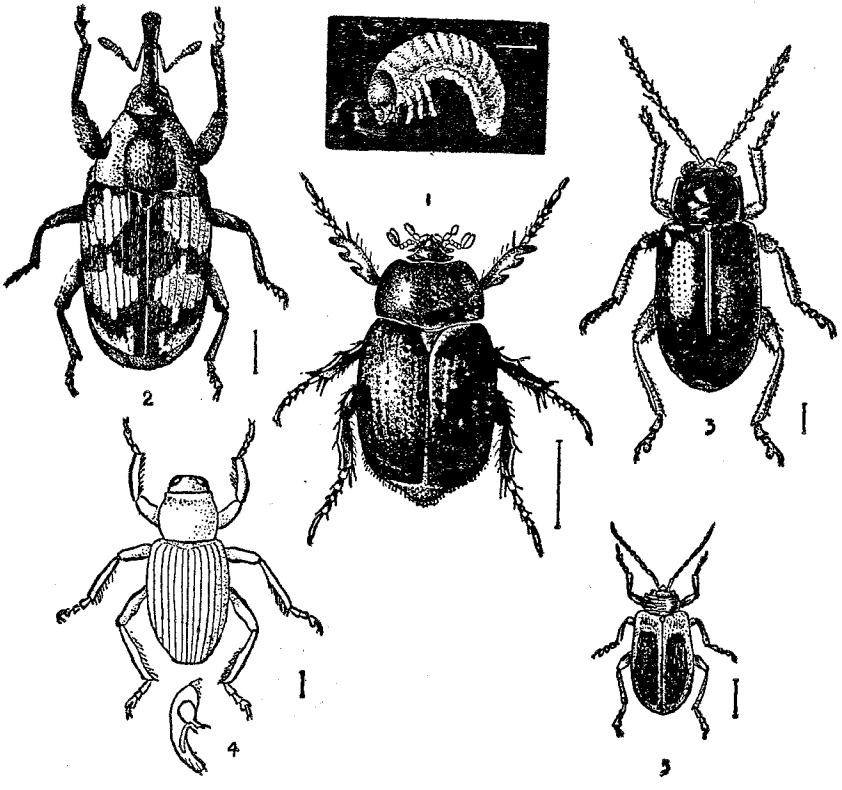


FIG. 107.—SOME BEETLES FOUND ON PADDY.

1 The rice cockchafer (*Phyllognathus*).
2 The rice leaf weevil (*Athesapeuta*).
3 The gregarious beetle (*Haltica*).
4 The rice root weevil (*Echinocnemus*).
5 The spotted leaf beetle (*Oides*).

FIG. 108.—BLISTER BEETLE SOMETIMES FOUND ON PADDY.
(*Epicauta* sp.)

[*From S.S.I.*

MINOR GRASSHOPPERS.—Besides the rice grasshopper (*Hieroglyphus*) noted above, a few other species also appear on the paddy plant generally as minor pests. These are (1) the Ganjam rice grasshopper (*H. orizivorous*, U.) which has the same habits as the rice grasshopper and occasionally found with it; this insect is often short, winged (2) the small grasshopper of paddy (*Oxya velox*, *Fb.* fig. 109); this is a very common insect found all over the plains of Southern India and occasionally in company with the rice grasshopper, and (3) when the paddy is in nurseries just before transplantation, numerous small grasshoppers do damage to the plants. These insects are called "*surface grasshoppers*" and include such common green and brown forms as *Acrotylus humbertiana*, S., *Heteropternis respondens*, W., *Aelopus affinis*, B., *Aelopus tamulus*, F., fig. 110, *Pachytylus danicus*, L., and *Pyrgomorpha conica*, Gl.

FIG. 109—PADDY SMALL GRASS HOPPER (*Oxya velox*, F.)
[*From S.S.I.*]

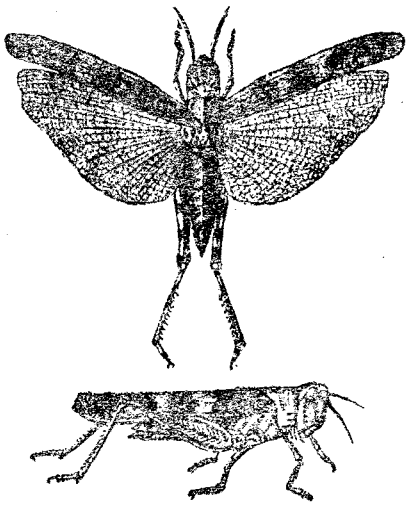


FIG. 110—SURFACE GRASSHOPPER,
(*Aeolopus tamulus*, F.)
[From Ind. Mus. Notes]

Most of these leaf feeding caterpillars, beetles and grasshoppers on paddy can be easily tackled by mechanical methods employed promptly; these include hand picking, bagging and netting. In very valuable and small plots, stomach poisons can also be sprayed or dusted. D.D.T. and B.H.C. being stomach poisons can also be used with advantage.

MINOR SUCKING BUGS.—Besides the sucking insects noted above numerous small bugs have been noted now and then in different places. All of them are very small mosquito-like insects which appear in swarms and suck up the juice from tender portions which fade if badly infested. Most of these fall under the group known as leaf hoppers and include besides the spotted jassid (*Nephotettix bipunctatus*) note on page 153, the white jassid(*Tettigoniella spectra*, Dt.) (fig. 96) which is bigger in size than the spotted jassid and has a uniform pale white colour, the brown leaf jassids (*Deltocephalus dorsalis*, M., and *Typlocyba subrufa*, M., fig. 111–2–5) two small insects noted in the Kistna and Malabar districts, the fulgorid hoppers (*Nilaparvata sordescens*, M., and *Nisia atrovenosa*, L., fig. 111–6–7), noted till now in Nellore and Kistna districts and the red spotted earhead plant bug (*Menida histrio*, F., fig. 111–1) often found on the ripening earheads in diffrent tracts but very rarely as a pest. Some of these leaf hopper bugs appear as pests during abnormal seasons and cause some appreciable damage. Light trap attracts them in numbers ; to supplement this method, other mechanical measures like netting and bagging and use of sticky winnows can also be adopted with advantage.

ROOT-FEEDING INSECTS OF PADDY.—A few insects are found occasionally attacking the roots of the paddy plant or the stem region very close to them. These include (1) the tube making caterpillar (*Ancylolomia chrysographella*, K.) (fig. 104–4) which occasionally appears as a pest on young paddy in the sandy coastal areas of North Malabar during the summer months. It is a smooth slender pale green caterpillar which feeds on the stem and roots of the very tender paddy seedlings and pupates in tubular galleries. The moth which is a medium sized one with straw-coloured wings often comes to lights, (2) the paddy cockchafer beetle (*Phyllognathus dionysius*, F., fig. 107–1) a dark brown medium sized beetle. The grub has the habit of attacking the roots of young paddy seedlings. Found occasionally in Kanara tract, and (3) the root weevil (*Echinocnemus oryzae*, M. fig., 107–4) a small grey weevil, the grubs of which attack the paddy roots and cause some injury. Noted till now only in Kistna and Guntur districts. This last insect appears to be similar to the rice water weevil (*Lissorhoptrus simplex.*) noted in Louisiana in America.

The treatment for these root-feeding insects consists in tackling the soil conditions by cultural and other operations.

Before leaving pests of paddy, reference may be made to two minor insects which are occasionally noted, viz., the rice stem borer fly (*Atherigona oryzæ*, M.) the maggot of a small bluish black anthomyiad fly and one or two species of very minute dark flea beetles (*Chætocnema* sp.) causing some damage to the foliage in the nurseries.

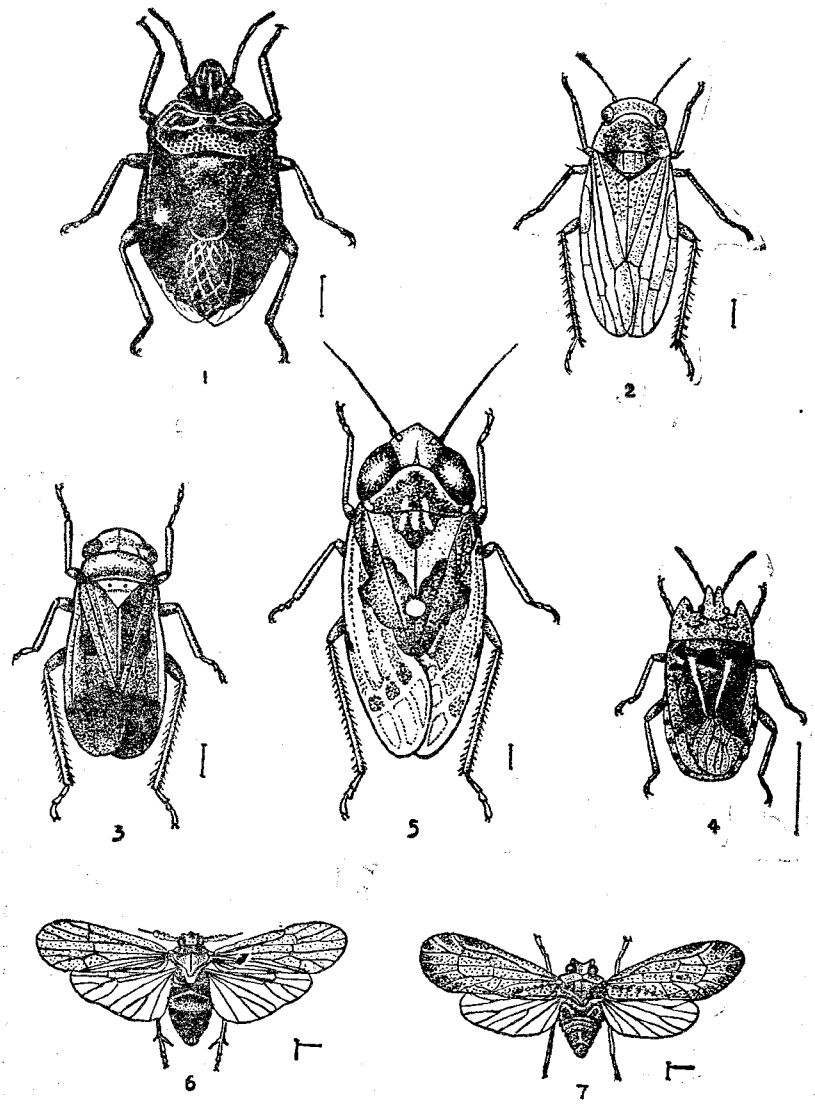


FIG. 111.—PADDY BUGS.

1 Earhead bug (*Menida*).
2 Leaf jassid (*Typhlocyba*).
3 Spotted jassid (*Nephotettix*).
4 Striped bug (*Tetroda*).
5 Leaf jassid of Kistna (*Deltocephalus.*)
6 Leaf fulgorid (*Nilaparvata*).
7 Do. (*Nisia*).

CHAPTER XII.

Insects affecting Millets, Wheat and Sugarcane.

Pests of Cholam, Ragi, Cumbu, Tenai, etc.

* CHOLAM INSECTS.

From the point of view of insect pests the sorghum plant in South India does not occupy such an important status as some do of the other major crops grown in the Province like paddy, cotton or groundnut. Unlike as in the case of some of the latter, the number of insect pests really causing appreciable damage to the crop is comparatively much fewer, and we very rarely hear of wholesale damage to this crop by insect pests as in the case of many other cultivated plants. It will be found that there are not more than half a dozen insects which might be put down as really important pests of cholam. Even out of this half a dozen, only three or four can be considered as major pests, occurring regularly year after year, having a wide distribution, and doing some noteworthy damage to the crop; the others very rarely attain pest proportions, and even when found as such, are often sporadic and confined to special tracts only. Under the first category may be included the earhead bug (*Calocoris angustatus*, L.), the moth borers (*Chilo zonellus*, S., and allied forms) and the red hairy caterpillar (*Amsacta albistriga*, M.). In the latter group we may bring together the grasshoppers of different kinds, including the Deccan grasshopper (*Colemania*), the fly maggot borer (*Atherigona indica*, M.), the shoot caterpillar (*Cirphis unipuncta*, H.), the shoot bug (*Perigrinus maidis*, D.), and plant lice (*Rhopalosiphum maidis*, F.). It may be added in this connexion that with the exception of one or two specific pests, most of the insects affecting cholam are also found to attack other millets like maize, ragi, cumbu, etc. One reason why borers and the earhead bug, which may be put down as the most important pests of cholam and other millets, continue to be perennial pests, season after season, is that in dry tracts sorghum is grown in some fields or other in every area, and though in individual plots alternate crops are grown in rotation there is no wholesale rotation in any wide area; this evidently gives a good chance for these insects to breed and multiply throughout the year easily and during favourable years assume the status of serious pests. Rotation of crops to have any salutary effect, from an entomological point of view, should be practised not for individual plots alone, as is generally done, but in appreciably extensive areas so that the pest will have no chances of multiplying and infesting the crop when next that crop is grown there.

* Andropogon sorghum.

THE CHOLAM STEM BORER (*Fig.* 112)—(*Chilo zonellus*, S.).—During the early stages of the cholam plant, when it is just a few inches high, one of the two borers affecting the plant is this caterpillar, the other being the fly borer referred to below (on page 167). The caterpillar burrows through the stem of the plant and kills the central shoot; and all the borer-affected plants show the dead central shoot known popularly as "dead heart." Grown-up plants are also infested, but the damage to young plant is far more serious. The insect is found in all the cholam tracts in South India.

Life history and habits.—The parent insect which is a medium-sized straw-coloured moth lays batches of scale-like flattish oval overlapping eggs generally on the undersurface of the leaves. These hatch into caterpillars which gradually bite their way into the stem and burrow into it feeding on the internal tissue and killing the central shoot in young plants. Pupation takes place inside the stem alone and the adult emerges after the pupation period. One life cycle from egg to moth generally occupies six to seven weeks. Both the egg and the caterpillar are often parasitised by wasps of different kinds. Besides cholam, the insect is found to breed on ragi and maize also. The damage by this insect is more serious when the plants attacked are young since the attacked shoot is completely killed; when grown-up plants are attacked; they are not killed but suffer in vigour and develop weak earheads.

Control measures.—In the case of all such borers none but preventive measures will be of any avail since external application of inseticides, etc., will not in any way affect the internal feeders. During the younger stages of the plant, the most effective and economic method is that of pulling out all young plants showing "dead hearts" when the fields are thinned, and disposing those pulled-out plants by feeding cattle with them or burying them deep; if thrown on the bunds or in field corners, the borers in them may emerge and infest healthy plants again. In tracts where these borers are regular pests, season after season, the seed rate may be slightly increased so that the later elimination of dead hearts will not very much affect the number of plants in the field; this is a method followed in Gujerat for the moth borer on young juar (sorghum). Another preventive measure which will go a great way in minimizing borer attacks is the necessity for giving proper attention to the crop remains left behind in the field after harvest. The stubble in the harvested fields often forms a very fertile harbouring place for the borer to develop and multiply before going into the next crop; these stubbles often give out fresh shoots and the borer finds them very favourable to breed in. Wherever possible, the stubble must be pulled out and not allowed to harbour the pest. As stated above, the damage to grown-up plants by moth borer is rarely serious and as such it may not demand any real control measures. In such a stage parasites of the borers are often found to do some good work in

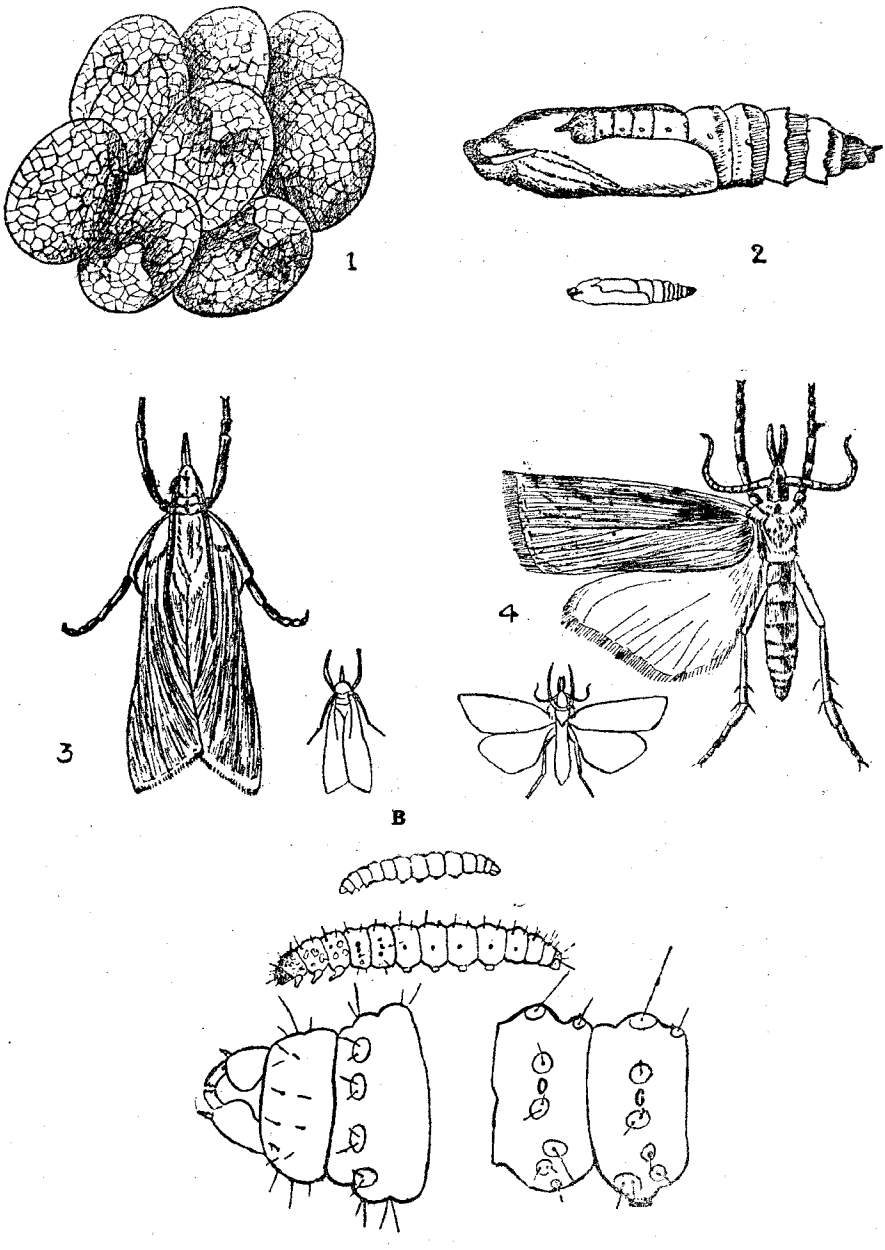


FIG. 112.—THE CHOLAM MOTH BORER (*Chilo zonellus*, S.)

A. Stages—

1 Eggs. 3 & 4 Adult. 2 Pupa.

B. The caterpillar. [*From S.S.I.*]

checking the pest as natural enemies. Two common parasites on this borer are a small red and dark braconid (*Microbracon chilocida, Ram*) (fig. 113) and a large ichneumonid (*Xanthopimpla pedator*, **F.**), (fig. 130).

THE EARHEAD BUG (*Fig.* 114)—(*Calocoris angustatus*, L.).—This is an active yellowish green bug known as *Navai puchi* in the Tamil tracts and has a wide distribution all over the Province especially in the Ceded districts and Coimbatore areas. It is one-fourth of an inch in length with fairly long limbs. Both the adult and the young ones suck up the sap from the tender portions of the plant, especially from the milky ripening earheads. In bad attacks each earhead may harbour hundreds of these which fly about like mosquitoes when the plant is disturbed. As a result of bug attack, the earhead becomes chaffy instead of containing ripe and healthy grains.

Life history and habits.—Shining pale whitish cigar-shaped eggs are thrust by the mother bug into the tender tissues of the shoots and the active orange-coloured nymphs that hatch out feed on the tender shoots, just like the adults, and after some days become mature winged insects. The insect is occasionally found on maize, cumbu and some grasses also.

Control measures.—If the pest is noted in the early stages of the crop it can be checked effectively by using hand nets and sticky winnows, and this will reduce the pest population considerably and check the damage on the ripening plants and ears. It will, however, be found difficult to tackle it in the later stages when the plants grow tall and it becomes difficult to adopt any such mechanical measures. Crop rotation and other cultural measures will have to be tried in tracts where the pest causes perennial trouble. Round about Coimbatore, crops sown before 15th March are reported to invariably escape the damage. The adjustment in the time of sowing, therefore, often offers some scope for control but the details have to be worked out for each tract. Among the insecticidal trials conducted recently, B.H.C. and D.D.T. dusts were found encouraging. A closely allied bug (*Megacoelum stramineum* W) is sometimes found with the common earhead bug as a minor or sporadic pest.

THE RED HAIRY CATERPILLAR (*Fig.* 90-1)—(*Amsacta albistriga*, W.).—The hairy larva of this moth is a very familiar and common creature found in most of the districts in South India and is one of the very well-known hairy caterpillars (*Kamblipuchi*, *Gongalipurugu*, *Korihula*) found attacking many of the dry and garden crops. It is specially destructive to groundnut in the rain-fed red soil areas of the central and eastern districts and in the Mysore plateau and it is one of the worst, if not the worst insect pest of the central districts in South India.

Life history and habits.—The female moth lays about a thousand eggs in batches of hundred or more on different green plants and these give rise to small caterpillars. These latter grow by feeding on cultivated crops of different kinds and within a month or two each caterpillar grows to about the length and size of our middle

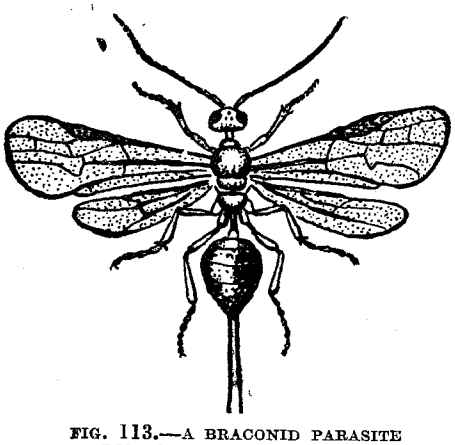


FIG. 113.—A BRACONID PARASITE (*Microbracon chilocida*, Ram) ON *Chilo* CATERPILLAR.

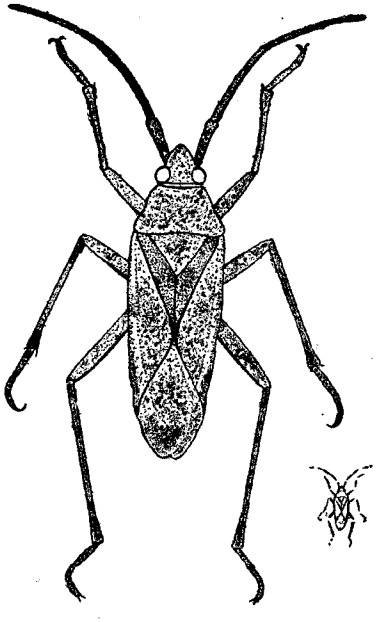


FIG. 114.—THE CHOLAM EARHEAD BUG. (*Calocoris angustatus*, L.)

[*From S.S.I.*]

finger and it is at this stage that the creature is very active and veracious. It then stops feeding and seeks its way under loose soil generally at the side of fields and hedges and changes into the pupa inside an earthen cell made before pupation (*see* fig. 161). The pupa is an apparently lifeless elongate, oval, cylindrical, reddish brown object looking more or less like a date seed; it remains in the soil for several months—generally from October-November to July-August of the following year. With the first monsoon showers of the next year, the underground pupa splits open and the winged moth emerges out of the soil to start the next generation in its life cycle. This creature is practically polyphagous and feeds on almost all green vegetation; but those that generally form its food material are pulses and other legumes like groundnut, redgram, etc., and others like castor, calotropis, etc. It causes very serious and substantial damage to groundnut and the millets. In the shape of natural enemies we find some wasps and tachinid flies parasitising the caterpillar, and occasionally a peculiar infectious disease, probably bacterial, kills them in numbers.

Control measures.—With promptness and co-operation this pest can be easily and effectively checked in the following ways :—

(1) *Hand-picking and destruction of the moths.*—To be done as soon as they emerge after the first monsoon rains; they are conspicuous by their cream colour and are sluggish, and juvenile coolies

can easily gather hundreds of them in a short time. This will check egg-laying and the subsequent appearance of the caterpillars.

(2) *Collection of egg masses.*—Some moths which might have escaped the notice of the farmer might lay eggs in a day or two and these are found in bright yellow batches. These can also be collected and destroyed.

(3) *Collection of pupæ.*—To prevent moths emerging, the underground pupæ can also be dug out by hand hoes from underbases of trees, shady fences, etc., near the infested fields. This should be done during the summer months. When, however, the eggs have been allowed to hatch into caterpillars and these latter have dispersed all over the fields, it becomes a difficult problem to check the pest. In this case, regular sweeping and destruction of the caterpillars, preventing their progress by making trenches, and such other measures can alone give some relief. The three methods described above are the best to adopt. A Pest Act is in existence for this pest in the infested districts.

THE DECCAN GRASSHOPPER (*Fig.* 115)—(*Colemania sphenarioides*, B.).—This insect which has no wings even during the adult stage has been found to do some appreciable damage to dry crops especially to tenai (*Setaria*) and cholam, and to a small extent to pulse and grasses in the Ceded districts. A few years ago it appeared in locust form and caused some serious damage in parts of Bellary, Kurnool, Deccan area and Mysore territory. The insect has not been noted in any of the other tracts of the Presidency it is evidently a pest which has gradually spread from the southern districts of Bombay. At present, though it is not absent in the above tracts, it is not found on such a serious scale as before though it is possible it may assume threatening proportions any time. The insect is a stout big grasshopper growing to two inches in length ; it is known as ' *Jitti* ' in Kanarese and ' *Midtha* " in Telugu. The loss caused by this insect during certain years is heavy ranging from 25 to even 100 per cent.

Life history and habits.—The life history is more or less similar to that of the paddy grasshopper. The eggs laid in batches 2 to 3 inches under the soil by the mother hopper during October-November of the previous year hatch into young hoppers in July. These develop by feeding on the growing crops during the period July to September and become mature when the crops are in ears. At this stage crops suffer heavily, the flowers and the ripening ears being devoured wholesale both by the maturing hoppers and the adults. The sexes mate and the eggs of the next generation are laid in October. Each egg mass contains from thirty to sixty eggs and these remain in the soil throughout the following summer until the monsoons in June-July.

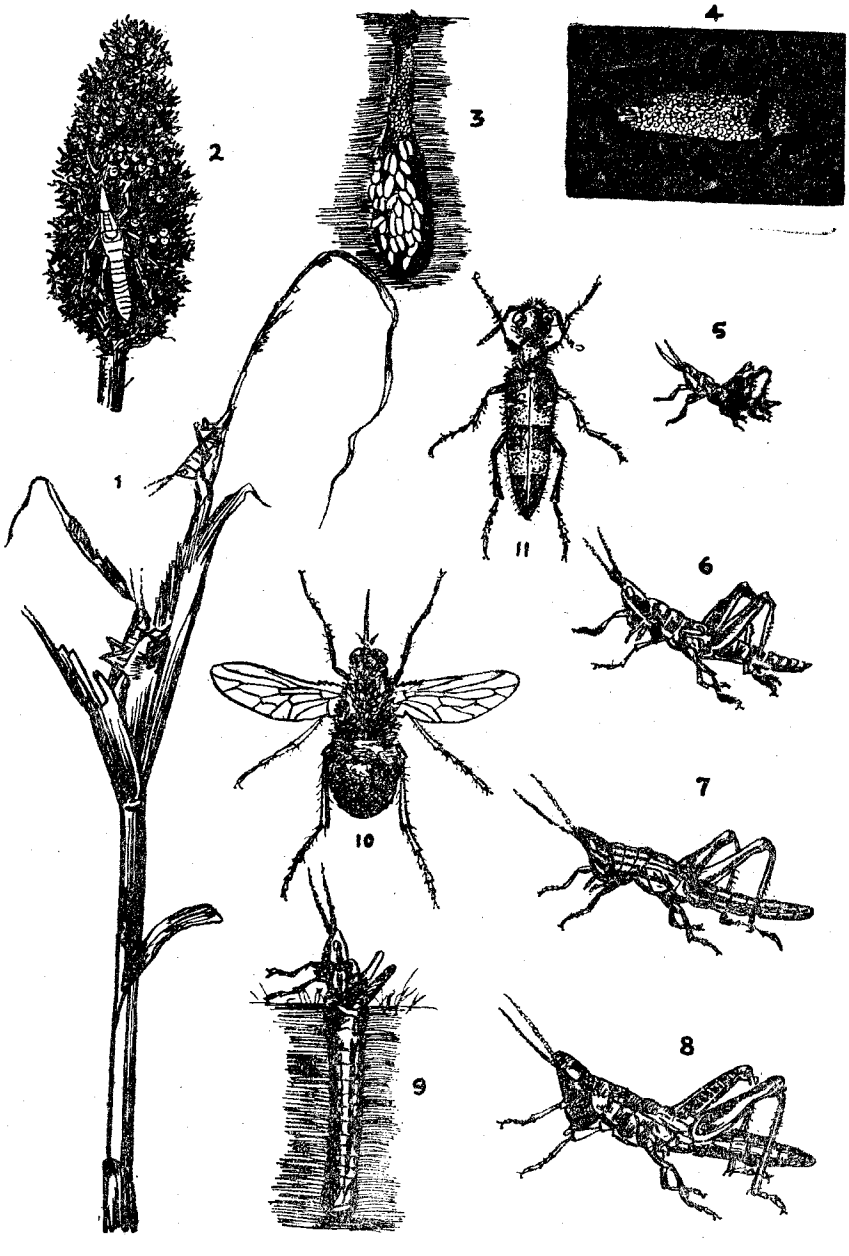


FIG. 115.—THE DECCAN GRASSHOPPER (*Colemania sphenarioides*, B.).

1 & 2 Young hoppers on the plant.
3 & 4 Egg.
5 & 6 Stages of hopper.
7 Male.
8 Female.
9 Egg laying.
10 Parasitic fly (Bombylid-*Systoechus socius*, W.).
11 Blister beetle (*Zonabris*) attacking eggs.

Control measures.—In the early stages the hoppers can be collected by hand nets, different hopper traps and bags and destroyed. When this opportunity is allowed to pass, it becomes a somewhat difficult task to tackle the creature when it has grown in size and has become more active. Even at this stage mechanical methods of using bags and hopper dozers will be found effective. The pairing adults can also be caught and destroyed to prevent egg-laying. Infested fields containing eggs may be ploughed deep during January-February so that the egg masses may be brought up to the surface to be destroyed by the heat of the sun. The egg-masses are often found subject to the attacks of parasites like the larvae of a bombylid fly (*Systœchus*) and a blister beetle [*Zonabris* (*see* figs. 115–10 and 11]. The problem appears to be nearing solution by the use of Hexyclan (B.H.C.) 7 per cent as dust. The chemical is reported to be extensively adopted with a remarkable degree of success in Bombay and Mysore, where the occurrence of the pest is an annual feature.

THE CHOLAM FLY (*Fig.* 98)—(*Atherigona indica*, M.).—This insect is a small dark fly the maggot of which bores into the stem of the young cholam plant and kills the central shoot. The insect is found in almost all the cholam areas. The damage is noted when the plants are less than a foot in height and it is occasionally serious.

Life history and habits.—The adult fly deposits eggs on the very tender stem of the young seedling and the maggots which hatch out of them bore into the stem and cause dead-hearts in infested plants. From the seed-like pupa which is found inside the infested stem, the dark grey fly emerges. Similar flies are found on *Varagu* and other millets occasionally.

Control measures.—Dead seedlings should be promptly pulled out when the fields are thinned and these should not be thrown in the field corners, but should be destroyed or properly disposed of to prevent fly emergence. The seed-rate may be increased to make up for this loss from borers.

MINOR PESTS OF CHOLAM.—Among other insects which occasionally infest cholam and cause some injury, the following may be noted :—

Sucking insects.—The Cholam shoot bug (*Perigrinus maidis* D.).—This is a small active greyish brown bug found in colonies in all its different life stages inside the tender shoots of cholam. The sucking up of the plant sap by these insects causes gradual fading and drying up of the affected shoots. This insect occasionally causes serious damage (fig. 116). It is found on maize also sometimes.

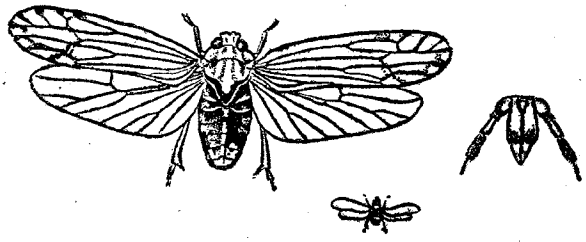


FIG. 116.—THE CHOLAM SHOOT BUG (*Perigrinus maidis*, D.)

[*After Distant*]

The Cholam aphid (*Rhopalosiphum maidis*, F.) is sometimes found in colonies inside unopened tender shoots. This pest does not generally demand any control measures since it is not so serious, and in most cases, predatory insects like lady-bird beetles, chrysopids and hover fly maggots keep the lice in check.

Three or four species of sap sucking stink bugs (*Nezara viridula*, L., *Dolycoris indicus*, S., *Agonoscelis nubila*, F., and *Piezodorus rubrofasciatus*, F.).—These are occasionally found on the tender shoots and earheads (figs. 117, 125, 275). The first one—known as the green plant bug—is the commonest of them. The best and most economical measure against these active creatures is the mechanical method of hand-picking or netting. During some seasons a species of thrips (*Taeniothrips jonnaphila*, Ram) is found in colonies on cholam ears.

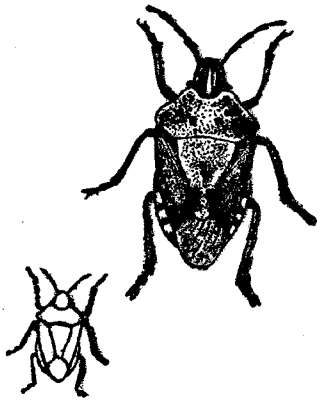


FIG. 117.—PLANT BUG.
(*Dolycoris indicus*).

[*From S.S.I.*]

Biting forms.—The cholam shoot caterpillar (*Cirphis unipuncta*, M.) is a stout smooth cylindrical creature found inside the tender shoots and feeding on the foliage. It pupates in the soil and the adult insect is a large-sized stout moth belonging to the group of cut-worms. Very rarely it is found serious on cholam (fig. 118). A closely allied species (*C. loreyi*, D.) is sometimes found with this caterpillar.

The cholam leaf roller caterpillar (*Marasmia trapezalis*, G.).—A slender yellowish green worm found at the leaf tips of cholam, folding or rolling up the foliage and feeding on the tissue. The pupa is also found in the roll or fold and the moth is a slender yellowish brown one with wavy brown markings on the wings. This insect is found all over the province and very rarely as a serious pest.

The earhead worms.—Two or three caterpillars have been noted on the cholam earheads feeding on the ripening grains. One, (*Eublemma silicula*,S.,) is a small pale brown noctuid moth and the other is a pyralid (*Stenachroia elongella*, H.), the caterpillar of which has the habit of webbing the grains in the earhead and feeding on them. A third is an arctiad (*Celama internella*) found on the earheads. Another caterpillar (*Simplicia robustalis*) is often found as a pest on dry cholam stalks stored for fodder (*See* p. 361, fig. 312).

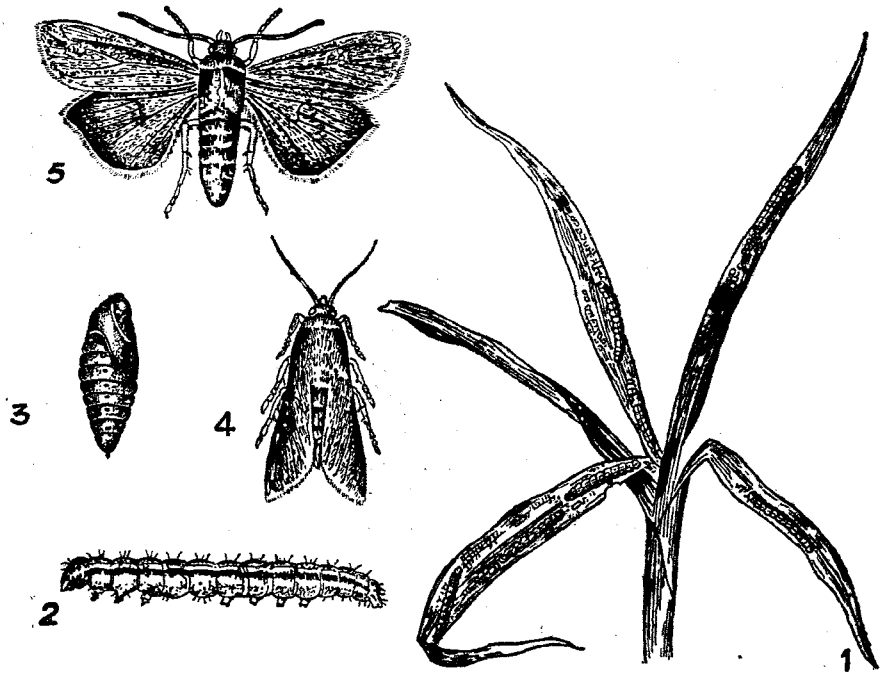
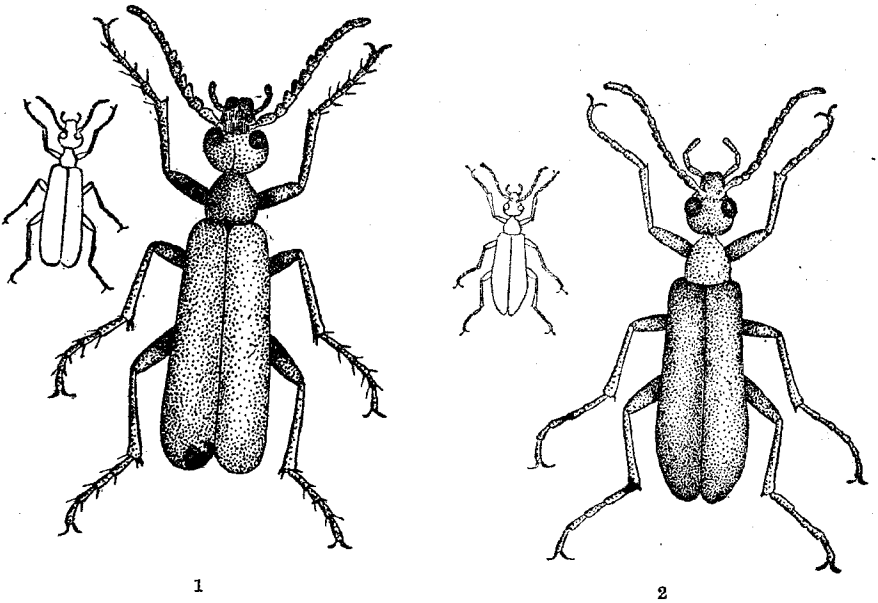


FIG. 118.—CHOLAM SHOOT CATERPILLAR.
(*Cirphis unipuncta*, H.)
1 Caterpillars on plant. 2 & 3 Caterpillar and pupa.
4 & 5 Moth.



1 2

FIG. 119.—BLISTER BEETLES ATTACKING CHOLAM EARS.

1 *Psalydolytta rouxi*, C. (yellow beetle).
2 *Cylindrothorax tenuicollis*, P. (green beetle).

Beetles of different kinds are occasionally found attacking the tender foliage, the flowers and the earheads. These include the grey weevil (*Myllocerus discolor*, B.) feeding on the tender foliage, the blister beetles (*Psalydolytta rouxi*, C. and *Cylindrothorax tenuicollis*. P. fig. 119) feeding on the blossoms and tender ears and some chafer beetles (*Anatona stillata*, N., *Heterorhina elegans*, F, *Chiloloba acuta*, W and *Oxycetonia versicolor*, F., fig. 92) on the earheads.

A gall fly (*Contarinia andropogonis*, F.) is occasionally found breeding inside tender ears making the seeds empty.

Species of the ground grasshopper (*Chrotogonus*) occasionally attack cholam and in parts of Ceded Districts another species (*Hieroglyphus nigrorepletus*, B.) attacks millets.

In some areas, during certain seasons, cholam suffers from the attacks of a mite (*Paratetranychus indicus*, *H.*) which turns the infested leaves into a reddish unhealthy colour.

* RAGI INSECTS.

As stated before, many of the insects found on cholam are often found on ragi also. The following insects are, however, specific pests of the ragi plant in South India.

THE RAGI PINK BORER (*Fig.* 120)—(*Seasamia inferens*, W.).—This borer is the caterpillar of a straw coloured stout noctuid moth. As in the case of the cholam borer it burrows into the stem

* *Eleusine coracana.*

and kills the central shoot. Though this insect is the common borer of wheat in Northern India it is found more commonly on ragi in South India. The caterpillar has a uniform pinkish brown colour and a smooth and cylindrical body. The damage caused by this pest is sometimes appreciable.

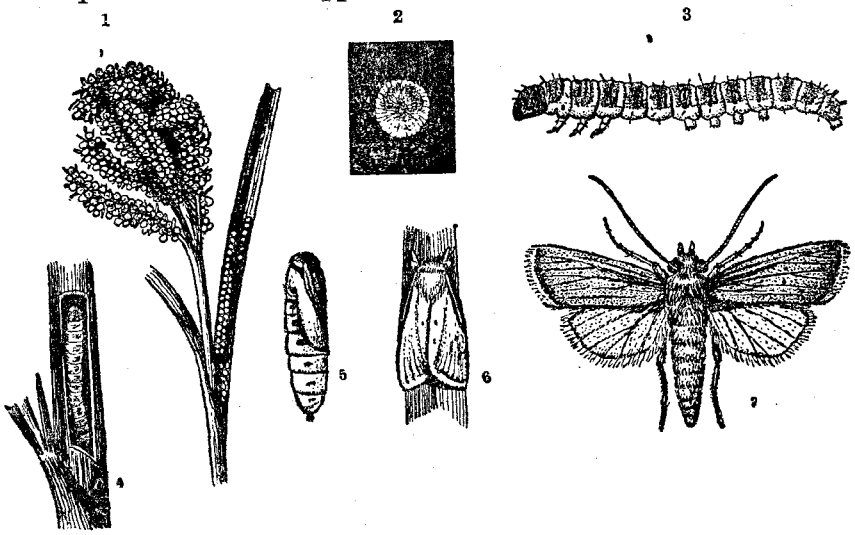


FIG. 120.—THE RAGI PINK BORER.
(*Sesamia inferens*, W.)

1 Eggs on plant. 3 Caterpillar. 5 Pupa.
2 Egg magnified. 4 Caterpillar in stem. 6 & 7 Moth.

Life history and habits.—Clusters of egg are laid inside the leaf sheaths of the stem and the young caterpillar on hatching out bores into the stem and gradually kills the central shoot. The caterpillars grow to about an inch in length and pupate in the burrow of the stem itself. One generation from egg to adult stage lasts from six to seven weeks. This borer is found also on wheat, maize, sugarcane, cholam and rarely on paddy. The caterpillar is often subject to the attacks of hymenopterous parasites.

Control measures.—The same measures suggested for the cholam borer will be found effective in this case also.

THE RAGI WHITE BORER (*Fig.* 121)—(*Saluria inficita*, W.).—This moth is a specific pest of ragi in South India, especially in the Coimbatore tract. The caterpillar is a stem borer similar to the other borers of millets and paddy, but has a cream white colour, and is found at the lower portions of the plant close to the soil surface. It has been rarely noted on tenai and has been recorded on paddy in Mysore. It is not, however, a serious major pest.

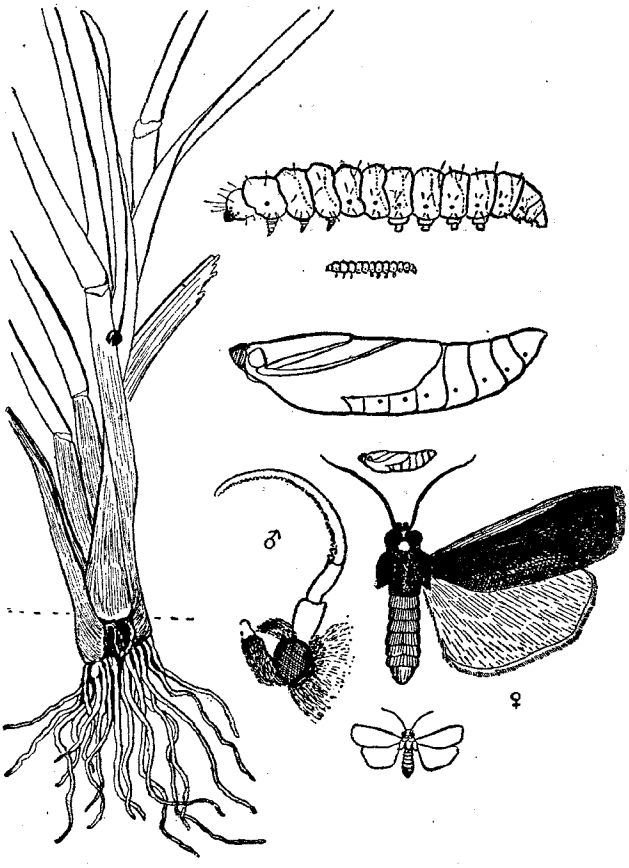


FIG. 121.—THE RAGI WHITE BORER.
(*Saluria inficita*, W-)
(Insect stages and attacked plant.)

[*From S.S.I.*]

Life history and habits.—The habits and life history of this insect are practically similar to the other borers. The caterpillar pupates in the stem itself and the adult insect which comes out is a dark brown medium sized moth with a pale white band along the margin of each forewing.

Control measures.—The same methods applicable to other borers. The moth has some attraction for lights and as such, light traps may be put up in the nurseries where the infestation starts, to trap the moths and prevent egg-laying.

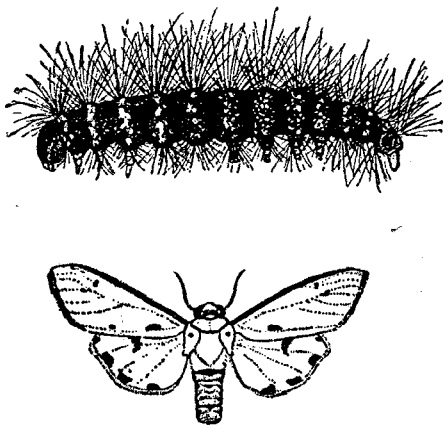


FIG. 122.—THE BLACK HAIRY CAETERPILLAR AND MOTH.
(*Estigmene lactinea, G.*)

[*From S.S.I.*]

The black hairy caterpillar.—(*Figs.* 90 *and* 122)—(*Estigmene lactinea,* G.).—During certain seasons ragi becomes subject to the attacks of this hairy caterpillar. It has been noted in Coimbatore and part of Tirunelveli and Ceded Districts. The caterpillar is known as the wooly bear caterpillar, because of its wooly black body and its bear-like locomotion.

Life history and habits.—Eggs are laid on the food plants and the hatching caterpillar grow by feeding on the leaves and ears and attain a length of about two inches. Pupation takes place in the soil. The adult insect is a beautiful large sized cream white moth with characteristic crimson markings on the head and body. It is noted occasionally on cumbu, cholam and other plants like horsegram, blackgram, etc. It is often found in company with the red hairy caterpillar and possesses the same habits.

Control measures.—As in the red hairy caterpillar, the emerging moths can be collected and the caterpillars shaken over a bucket of water containing some kerosene.

THE RAGI LEAF NOCTUID—(*Fig.* 123)—(*Laphygma exigua.* H.).—This insect is one of the cut-worm moths having a very wide distribution all over Peninsular India and attacking several cultivated plants. It sometimes causes appreciable damage in ragi nurseries in the Northern Circars and other tracts. It is also an occasional pest of onions, chillies, lucerne, etc. The caterpillars are smooth brownish green creatures which, in bad cases, cause damage similar to the army worm in the ragi nurseries.

Life history and habits.—Eggs are laid in clusters on the lower portions of young plants and the light green dark headed caterpillars which hatch out feed on the green portion and grow

to about an inch and a half in length. Pupation takes place under the soil and the adult is a dark brown medium sized moth.

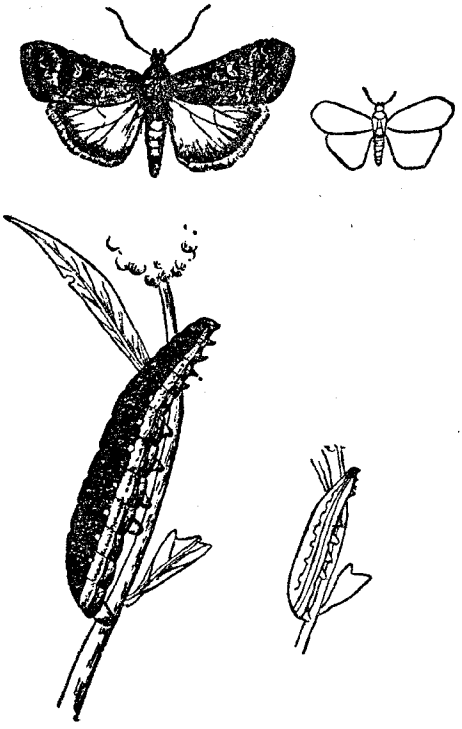


FIG. 123.—LEAF NOCTUID ON RAGI,
(*Laphygma exigua*, H.)
(Caterpillar and moth.)

[*From S.S.I.*]

Control measures.—Both mechanical and insecticidal methods can be adopted. In the nurseries, the former are easier and far more economical. In bad infestation on a wide area stomach insecticides like lead arsenate or Calcium arsenate can be applied.

RAGI ROOT APHID (*Fig.* 124)—(*Tetraneura hirsuta*, B.)—These are minute pale white lice found doing some damage to the roots of ragi plants. The pest, though very rarely serious, has been often noted only in the Coimbatore area. The external evidence of the presence of this pest is the gradual fading away of the badly infested plants and the presence of ants visiting the roots: such plants when pulled out will show colonies of the lice attached to the roots.

Control measures.—The irrigation water may be mixed with Crude-oil emulsion, fish-oil soap or tar water; this will kill the underground lice and check their depredations.

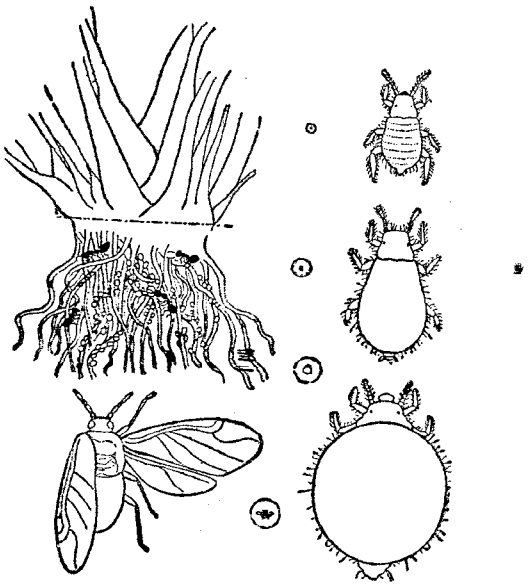


FIG. 124.—RAGI ROOT APHID.
(*Tetraneura hirsuta*, B.)
(Ragi roots with the lice and stages of the louse with winged female.)
[*from S.S.I.*]

Minor insects of Ragi.—In addition to the above insects there are a few others which occasionally infest ragi in different places. These include surface grasshoppers of different kinds as *Chrotogonus, Oedalius*, etc., flea beetles (spp. of *Choetocnema and Lema*) and the groundnut thrips (*Heliothrips indicus* B.) chiefly in the nurseries; the cholam stem borer (*Chilo*) and leaf weevils (*Myllocerus* spp.) later. The species of plant lice (*Rhopalosiphum maidis* F.) is also found on Ragi in parts of Mysore. The caterpillar (*Simplicia robustalis* G.) noted on dry cholam stalks attacks ragi also. A Semilooper (*Hyposidra talaca*, H) has been noted on Ragi in Mysore.

CUMBU[1] INSECTS.

The most important pests of this crop are the Red hairy caterpillar (*Amsacta albistriga*, W.) in most tracts, the Deccan grasshopper (*Colemania sphenarioides*, B.) in the Ceded Districts, the Black hairy caterpillar (*Estigmene lactinea*, Cr.) in some central area and the green plant bug (*Nezara viridula*, L. fig. 125) on the earheads, chiefly in the Southern districts. The seed bug of groundnut (*Aphanus sordidus*, F. fig. 165) occasionally attacks just harvested cumbu ears. Blister beetles noted under cholam, some cockchafer beetles (*Spilophorus* spp.) and the wingless grasshopper (*Orthacris*, fig. 126) are also met with on this crop occasionally. The same control measures suggested for cholam may be adopted in this case also.

[1] *Pennisetum typhoideum.*

Another stink bug (*Eusarcocoris guttiger* Th.) also attacks cumbu in some areas (Fig. 94–2).

TENAI [1] INSECTS.

TENAI EROTYLID (*Fig.* 127)—(*Anadastus parvulus*, W.).—The only specific pest worth mentioning in connexion with this crop is this stem boring erotylid beetle. It has been noted chiefly

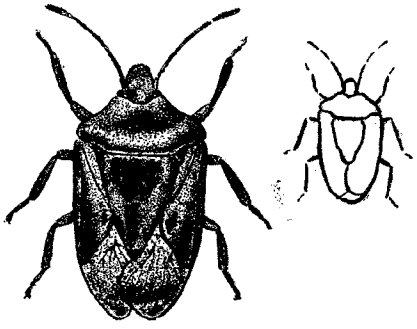


FIG. 125.—THE GREEN PLANT BUG.
(*Nezara viridula*, L.)

[*From S.S.I.*]

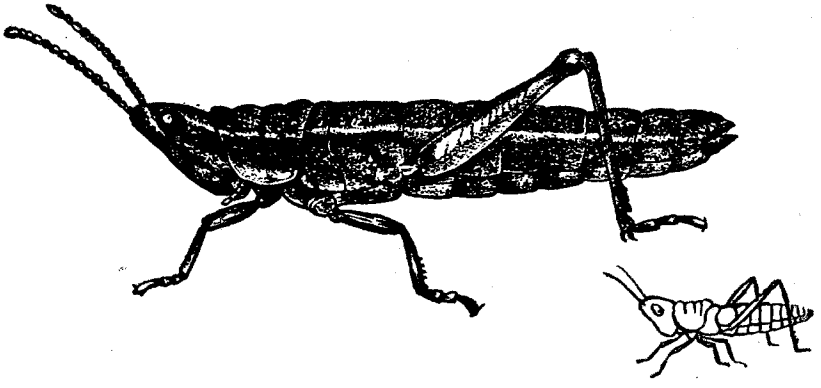


FIG. 126.—THE WINGLESS GRASSHOPPER OF MILLETS.)
(*Orthacris simulans*, B.)

[*From S.S.I.*].

[1] *Setaria italica.*

in the Coimbatore area only till now. The insect is a small smooth beetle having the head and thorax red and the wing covers of a deep blue color. The grub of this beetle bores into the stem of the tenai plant and causes borer damage showing the typical withering and drying up of the earheads.

Life history and habits.—Small cigar shaped eggs are thrust by the beetle singly into the tissue of the stem and these hatch into pale yellow grubs. The grub makes a neat ring around the stem from inside and remains feeding in this hollow where it pupates when full-fed. A full-grown grub is about a third of an inch and has an yellowish white color with a pair of short chitinous spines on the surface of the anal segment. The pupa is yellowish at the beginning but gradually turns brown mottled with dark brown patches. The adult beetle emerges through an opening in the stem previously made by the grub. One life cycle of the beetle occupies about six to seven weeks (*vide* Isaac's paper, 1919).

Control measures.—The ordinary measures for borers should be adopted. The beetles when in evidence may be collected and destroyed to prevent egg-laying.

Few other insects attack tenai seriously and these are mostly the same which are found on cholam, ragi, etc.

Other millets like Varagu (*Panicum* spp.) occasionally suffer from the attacks of stem flies like *Atherigona destructor* M., species of leaf weevils like *Myllocerus dentifer* F. and flea beetles. One of the latter attacking *Panivaragu* is a small dark bluish beetle (*Choetocnema pusoensis*, M.)

Hardly any of the other millets grown in different parts of the province suffers from any serious insect pest. Occasionally stem boring flies or leaf weevils may be noted as minor pests.

MAIZE INSECTS.

The insect pests of maize are mostly the same as those found on cholam and ragi, the commonest ones being the stem borers (*Chilo* and *Sesamia*), the shoot bug (*Perigrinus*), the cholam aphid (*Rhopalosiphum maidis*) the ragi noctuid (*Laphygma*) and grasshoppers of sorts.

WHEAT INSECTS.

On wheat which is not extensively grown in South India very few serious pests have been met with till now. These include the ragi pink borer (*Sesamia inferens*, W.) called the wheat stem borer in Northern India, plant lice (chiefly *Toxoptera graminum*, R.) and

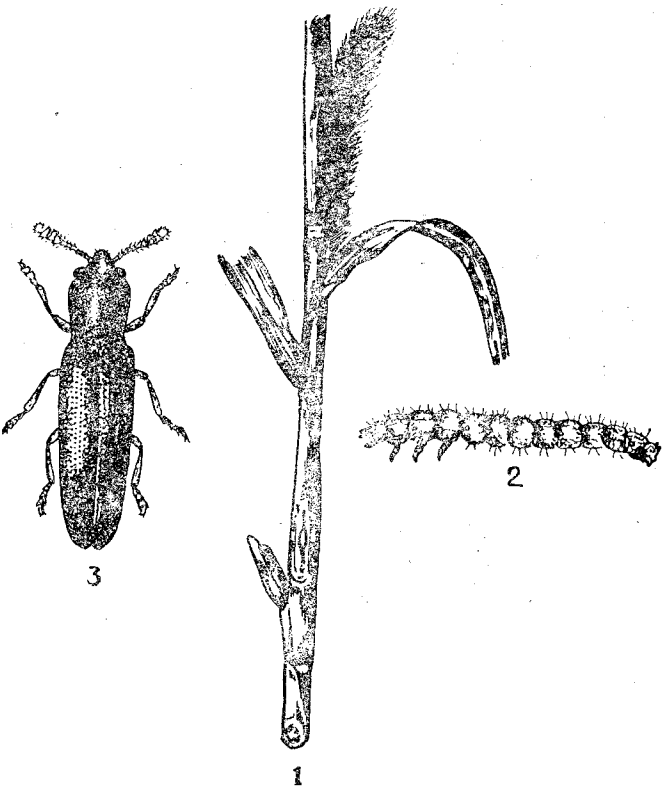


FIG. 127.—TENAI EROTYLID.
(*Anadastus parvulus*, W.)
1. Egg inside stem of plant. 2. The grub. 3. The beetle.

termites (*Microtermes obesi*. H.). The latter often cause some damage in the fields and clumps of wheat are found to dry up due to white-ant damage. In very valuable plots and in bad infestations of plant lice contact insecticides may be applied. For white-ants the irrigation water may be mixed with crude-oil emulsion or tar water. The radical remedy for termites is to tackle the nests in the vicinity and destroy the inmates of the colony, especially the queen ants. Deep ploughing in termite-infested areas will also act as a preventive against these underground pests. Some flea beetles, surface grasshoppers and some weevils (*Tanymecus* spp.) are now and then found on young wheat plants.

Sugarcane Insects.

The chief insect pests of sugarcane which is a very important industrial crop in the province are not many. They include the moth borers, the termites, the leaf hopper, the mealy bugs and the mealy wings. Of these the borers are the most important.

The moth borers include two or three different species of pyralid moths—*Chilotroea infuscatellus*, H., and *Proceros indicus*, W., which are typical stem borers, and the white borer (*Scirpophaga nivella*, F.) which bores into the top shoot from above.

THE STEM BORERS (*Fig.* 128 *I, III*)—(*Chilotroea and Proceros*).—These are pale straw colored pyralid moths the caterpillars of which bore into the growing stem of the sugarcane plant and often cause serious damage. The more important one in South India appears to be *Chilotroea infuscatellus*, H. Both the very young plants and the growing canes are affected, but the damage to the former is far more serious since the infested shoot is killed. The insect is found in all the important cane areas in Coimbatore, in South Arcot, in Chittoor, in the Ceded districts and in the Northern Circars. The presence of dead hearts in a young field is a sure sign of the presence of the pest in the field. The other borer (*P. indicus*, W.) is one which is usually found to attack grown up canes causing comparatively much less damage. It is also widely distributed and occasionally becomes serious.

Life history and habits.—The lifehistories of these borers are more or less similar. Pale scale like flattish overlapping eggs are laid in batches on the surface of the leaves; the caterpillars that hatch out from these find their way to the central portion of the plant, bite a hole through the stem and enter it; here they grow feeding on the inner contents and causing the characteristic damage to the central shoot. A full-grown caterpillar which measures about an inch and a half has a sordid white color with the body surface often mottled with dark brownish marks, short setae and tubercles. Pupation takes place inside the stem and the adults that emerge are straw-colored moths generally having the palpi pointed forwards. One generation takes about six weeks (the egg period 3–4 days, pupal stage 6–7 and the larval stage about a month).

THE WHITE BORER (*Fig.* 128 *II*)—(*Scirpophaga nivella*, F.).—The caterpillar of this moth bores into the stem of the growing sugarcane plant from the top shoot and causes damage to the growing plant. Plants attacked by this borer are easily detected by the peculiar bunchy side shoots given off from the attacked central top shoot. This insect very rarely assumes pest proportions in South India. Another closely allied species (*S. monostigma Z.*, the moth with a dark spot on each wing, fig. 129) is sometimes found in company with this white borer.

Life history and habits.—The lifehistory is similar to the two borers noted above. The caterpillar and the moth are however quite different in appearance from the latter. The caterpillar has a cream yellowish white color and the moth is easily distinguished by its uniform cream white color, with a crimson hairy anal tuft in the gravid female. Occasionally the pink borer of ragi (*Sesamia inferens*, W.) also attacks sugarcane in some tracts.

SUGARCANE INSECTS OF S. INDIA

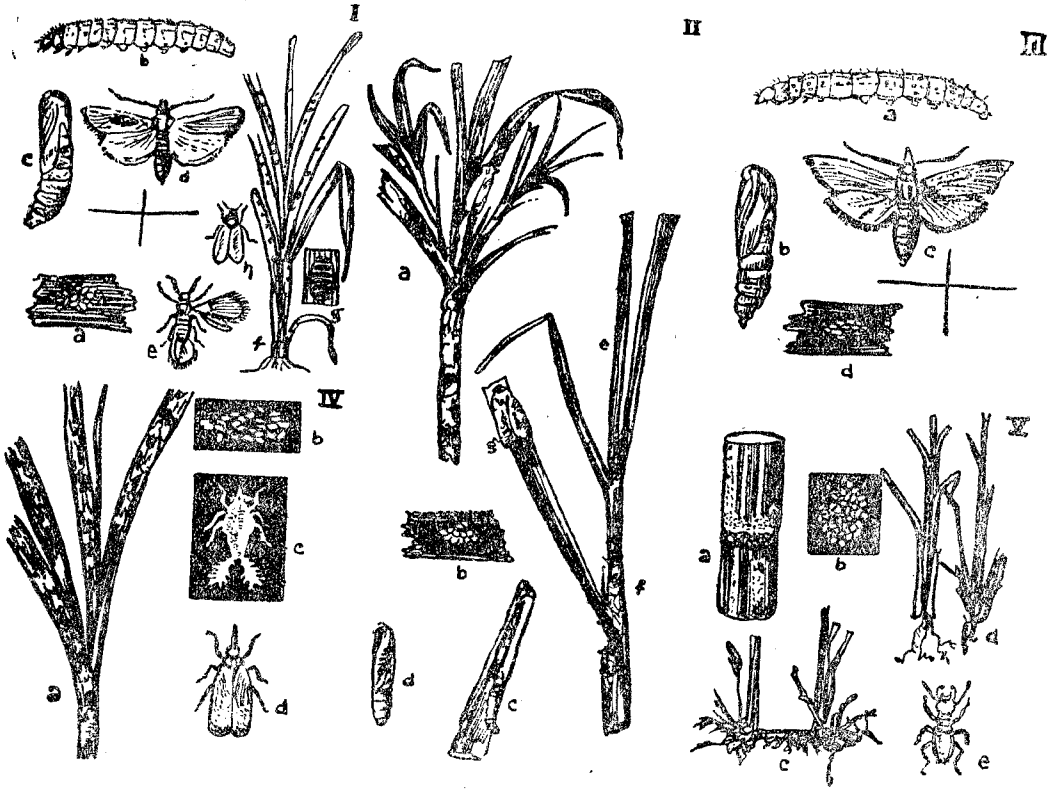


FIG. 128.—SOME IMPORTANT SUGARCANE PESTS.

I (*a*) to (*d*) Moth borer (*Chilotroea*) stages.
(*e*) Egg parasite (*Trichogramma*).
(*f*) to (*h*) Mealy wing.
II (*a*) to (*d*) White borer (*Scirpophaga*).
(*e*) to (*g*) The pink borer (*Sesamia*).
III Stages of borer (*Proceros*).
IV The cane fly stages (*Pyrilla*).
V (*a*) & (*b*) Mealy bug (*Saccharicoccus*).
(*c*), (*d*) & (*e*) White-ant and its damage.

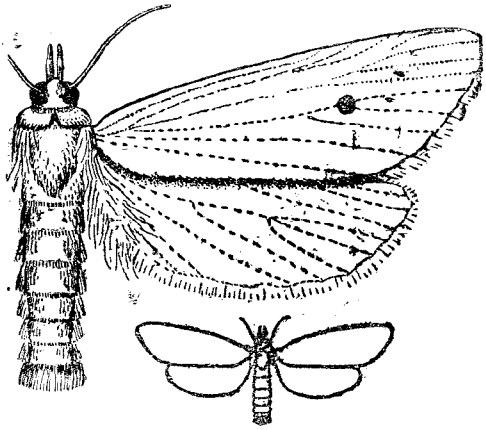


FIG. 129.—THE WHITE BORER MOTH.
(*Scirpophaga monostigma*, Z.) [*From S.S.I.*]

Control measures.—Being internal feeders, only preventive measures will be found practicable and economic. Planting of disease and borer free setts, pulling out and destroying first attacked plants or top shoots and wherever possible, collection and destruction of the egg masses will go a great way on minimizing borer attacks.

These borers are, of course, checked to some extent by various hymenopterous parasites attacking the eggs, larva and the pupa, but their work as natural enemies is not often found sufficient to keep these pests under proper control.* In other countries as well as at Mysore and Madras " biological control " of the borers with a well-known egg parasite [*Trichogramma minutum*, R. (fig. 128 I (*c*)] which is practically found all over the world is being tried and it remains to be seen how far it proves efficacious in this country.

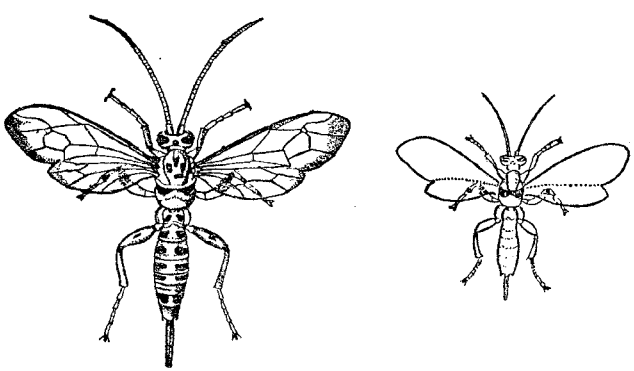


FIG. 130.—ICHNEUMON WASP PARASITIC ON BORERS.
(*Xanthopimpla pedator*, F.) [*From S.S.I.*]

* Two egg parasites a chalcid (*Trichogramma minutum*) and a scelionid (*Phanurus beneficiens*, Z.) and a larval parasite the braconid (*Stenobracon nicivillei*) are the chief parasites; occasionally an ichneumon (*Xanthopimpla pedator*, F., fig. 130) is also found on these borers. The chalcid *Tetrastychus ayyari*, R. is a common pupal parasite of these moth borers.

TERMITES (*Fig.* 128 *V*)—(*Odontotermes obesus*, W., and *Eutermes hœmi*, W.)—In many cases, especially in those areas which are termite infested, these insects, especially *O. obesus*, W. attack cane setts planted underground and severe damage is often caused which prevents the germination of the setts; the setts and the buds are all completely eaten up leaving only the hollow outer rind of the sett in the soil. The species *Eutermes hœmi* appears to be a leaf eater and often swarms of this ant appear in the evening on young seedlings, cut out pieces of the leaf blades and strip the leaves outright skeletonizing the few leaves of the young seedling; plants raised from seeds often suffer very badly in this manner.

Control measures.—The radical measure against these pests is that of clearing the area of all termite nests before starting cultivation; it is important that the queen ants in these nests which are capable of producing thousands of young ones should be collected and destroyed. As a temporary measure of relief, when the infestation is found in a planted field the irrigation water may be mixed with crude oil emulsion, fish-oil soap, tar water or D.D.T or B.H.C. In some tracts serious and wholesale losses of seedlings are reported from termite attack.

THE CANE LEAF HOPPER (*Fig.* 128 *IV*)—(*Pyrilla perpusilla*,* W.).—This is a very active straw colored bug with the head prominently drawn forwards as a sort of rostrum. It is found in most cane areas of this province, and other parts of India also. Though till recently it was very rarely found in pest condition, nowadays it is becoming a fairly serious pest—especially in parts of South Arcot and the Northern Circars. The insect, the damage it causes and its life history and habits are all more or less very similar to the notorious leaf hopper of Hawaii (*Perkinsiella saccharicida*. K.). Swarms of these insects in all stages are found on the tender and ripening foliage in infested fields and the drainage due to the sucking up of the plant sap by millions of these creatures causes fading and drying up of the leaves and the plants present a sickly and blighted appearance. When such plants are disturbed hundreds of adults and nymphs hop about on all sides.

Life history and habits.—Batches of pale greenish yellow eggs often numbering twenty or more are laid by the mother insect on the under-surface of leaves generally in a mass of white fluffy filamentous waxy material which the insect secretes. The young ones which hatch out are active pale brown hopping creatures with a pair of characteristic long wax covered anal processes. These nymphs suck up the plant juice and grow into adults after the usual moults. One cycle of the insects takes about two months from the egg to the adult stage. In a badly infested area the insect can be found in all its different stages. Similar to mealy bugs and other small leaf hoppers this insect exudes a sweet fluid 'Honey dew' on the foliage; this attracts numerous other insects and also the black sooty mould which covers such infested plants presenting a very

* Now known as Dictyophara Pallida.

sickly appearance. Though generally found in pest form only on sugarcane, the insect is occasionally noted in small numbers on maize and cholam also.

Control measures.—Mechanical methods in the shape of destruction of eggmasses which are easily visible, bagging of the nymphs and adults and the use of light trap have been found to control the pest to a great extent. Spraying of contact insecticides though effective, is not always found practical in large areas where it is found difficult to move the spraying apparatus and also on account of the active habits of the insect. BHC. 5 per cent effectively controls the pest. The eggs of the insect are parasitised by hymenopterous insects and the artificial utilization of such parasites can also be tried wherever possible. The intensive cultivation of sugarcane in any area all through the year gives such insects very favourable conditions to become perennial pests; this is what is being noted in South India where this insect was not a serious pest until recently.

THE CANE MEALY BUG (*Fig.* 128 *V ab.*)—(*Saccharicoccus sacchari, G.*)—This is a small pinkish oval creature found often in hundreds attached to the lower nodes of the growing cane protected by the sheathing leaves and covered over by a thin white waxy powder; the insects are inactive and anchor themselves chiefly at the nodes of the cane and suck up the cane juice. Their attack, in addition to causing sap drainage, also attracts fungi of different kinds due to the 'honey dew' secretion. This insect is like the *soorai* bug of paddy.

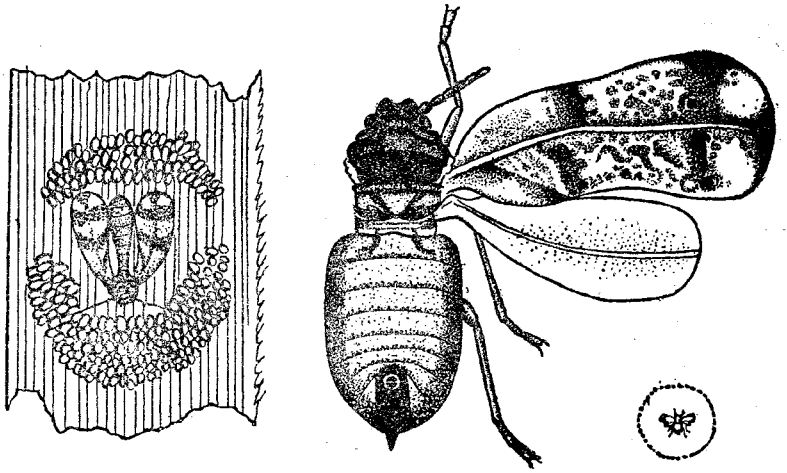


FIG. 131.—CANE MEALY WING.
(*Neomaskellia bergi*, S.)
(On the left—Egg-laying.)
[After Zehntner]

Life history and habits.—These are typical mealy bugs where the female insect gives rise to hundreds of young ones, often by parthenogenesis ; in a short time the insects multiply remarkably in numbers and the young larvae distribute themselves in the field. Ants also play their part in helping their dispersal. These mealy bugs are often attacked by various natural enemies like wasps, lady-bird beetles, etc., and these latter sometimes keep the pest in efficient check.

Control measures.—The selection of healthy, pest-and disease-free setts for seeds is one of the best prophylactic measures, since carelessness in this selection often helps the introduction and spread of this pest in any newly planted area. Proper disposal of badly infested leaf sheaths and canes, and wherever possible the encouragement of natural enemies will tend to keep the pest under control. Wherever practicable the old leaf sheaths may be removed and the infested canes sprayed with a contact insecticide.

THE CANE MEALY WINGS (*Fig.* 128 *I and* 131)—(*Aleurolobus barodensis, M. and Neomaskellia bergi, Sign*).—These two insects known as sugarcane white flies are found as occasional pests of cane in different parts of South India causing drainage of sap from the foliage and affecting the vigor of the canes. The adults are very small delicate insects with their wings and body covered with white powdery bloom ; they are active, able to fly and thus help in distributing themselves, from field to field. The developing nymphs are more or less stationary and on badly infested leaves these and their dark mealy covered nymphal cases are found in thousands.

Life history and habits.—Small shining eggs are laid by the mother insects on the leaf generally along the middle and on the lower surface of it. *Neomaskellia bergi* has the habit of laying the eggs in a circle or concentric semi circles (fig. 131). In about 3 to 4 weeks the young ones from these eggs become mature winged creatures. *A. barodensis* is pale greenish with the wings uniform pale grey ; in *N. bergi* the wings are speckled with dark-brown spots and marking and can be easily distinguished.

Control measures.—The prompt clipping and destruction of early attacked foliage will prevent pest multiplication. In bad cases, a spray with a contact insecticide can also be employed with advantage.

Among minor pests of sugarcane found in different parts of the province the following may be noted :—

(1) the scale insect (*Aclerda japonica*, N.) attacking the stem, occasionally noted in parts of Salem ;

(2) the black leaf hopper (*Assamia moesta*, W. fig. 132) with curious long wings ; though often found in numbers on the foliage it is rarely a pest ;

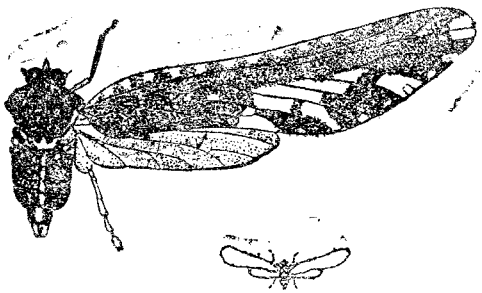


FIG. 132.—THE SUGARCANE BLACK LEAF HOPPER.
(*Assamia mœsta*, W.)

[*From S.S.J.*]

(3) cane root lice (*Tetraneura coimbatorensis*, G.) causing damage similar to the ragi root louse ;

(4) the rice grasshopper (*Hieroglyphus banian* F.) is sometimes found as a minor pest on young cane crop in parts of the Northern Circars.

(5) the leaf tip thrips (*Bregmatothrips ramakrishnae* B.) which occasionally makes the tips of tender leaves roll up and turn pale ; fig. 97-4. Two other species of thrips have also been noted on cane leaves in Coimbatore and Northern Circars (*Fulmekiola indica* R & M and *F. saccharicida* R. & M.).

(6) the cane butterfly (*Telicota augias*, L.) the caterpillar of which feeds on the leaf (fig. 133) ;

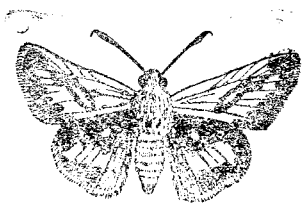


FIG. 133.—THE CANE SKIPPER
(*Telicota augias*, L.)

[*From S.S.I.*]

(7) the sugarcane hispa (*Physodonta cuspidata*, W.) the small spiny black beetle which breeds on the leaf and is in general form like the rice hispa ;

(8) the rhinoceros beetle (*Oryctes rhinoceros*, L.) sometimes found boring into growing cane (fig. 264) ; this is specially so when manure pits are in the vicinity of cane fields.

CHAPTER XIII

Pests of Pulses and Oil-seeds.

PULSES—REDGRAM.

Among pulse crops the redgram (*Cajanus indicus*) plant appears to have more insect associates than the others, though the really serious and major pests among them are not more than three or four.

THE GRAM CATERPILLAR, (figs. 170 *and* 284)—(*Heliothis armigera, F*).—This caterpillar is the larva of a stout built yellowish brown moth known as the 'Cotton bollworm moth' in America. Though it is found feeding in various parts in India it is very rarely found as a serious cotton pest. The caterpillar not only defoliates the tender parts but also bores into the gram pods and feeds on the ripening seeds.

Life history and habits.—The insect belongs to the family of cutworms, though the habits are not altogether similar to them. Shining greenish yellow eggs, spherical in shape and beautifully sculptured are laid singly on the tender parts of the food plant. The young caterpillars feed on the tender foliage and as they grow, they bore into the pods and destroy the seeds. A full grown caterpillar is elongated and cylindrical growing to about an inch and a half in length; its color is variable though generally it is green having light longitudinal or grey streaks along the sides. The body surface has short setae and tubercles. Pupation takes place in an earthen cocoon in the soil near the plant; the pupa is dark brown and about half an inch in length with a small sharp spine at the anal extremity. As a pod borer it is often found exposing its posterior half with its anterior portion inside the pod or fruit it attacks. This is an important pest and often causes serious damage. The caterpillar is polyphagous having been noted on a variety of plants such as bengalgram, cotton, groundnut, tomato, opium, peas, ganja, etc.

Control measures.—This is one of those insect pests which is hard to control. If noted early, dusting or spraying with stomach poisons may be effective, but since the grown up caterpillars are pod borers spraying later on will not have the desired effect. Hand-picking of the caterpillars is the only feasible method in this case. The caterpillar is sometimes checked in nature by fly and wasp parasites though these are rarely very effective.

THE REDGRAM PLUME MOTH (*Figs.* 134 *and* 135)—(*Exelastis atomosa*, W.).—This insect is a specific pest of redgram in many parts of India. The caterpillar is a short greenish brown creature; it is a typical borer cutting through the pod and feeding on the seeds inside. Sometimes appreciable damage is caused by this insect.

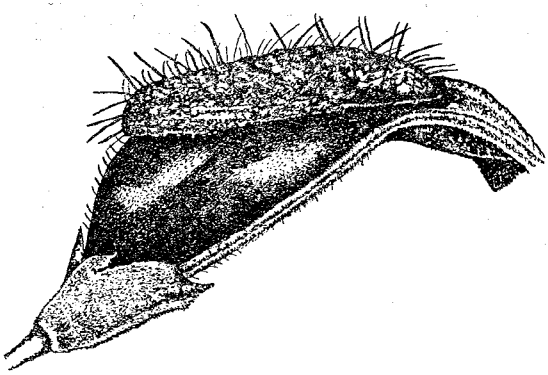


FIG. 134.—PUPA OF REDGRAM PLUME MOTH.

[*After Lefroy*]

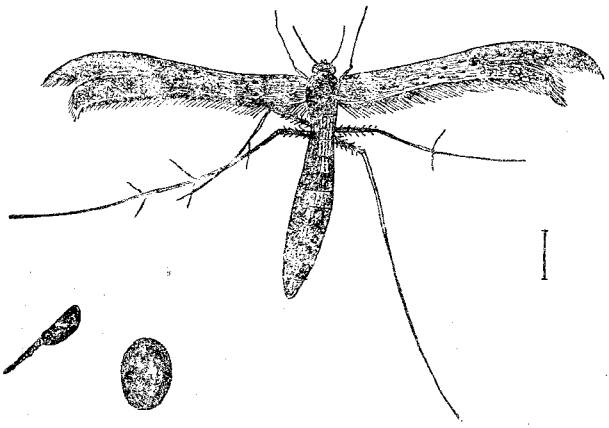


FIG. 135.—REDGRAM PLUME MOTH.
(*Exelastis atomosa*, W.)

[*From S.S.I.*]

Life history and habits.—Minute single eggs are laid on the tender shoots or pod and the caterpillars which hatch out first scrape the pod surface and gradually cut a hole and thrust the head into it and feed on the seeds from outside. The full grown caterpillar is about half an inch in length, greenish brown and fringed with short hairs and spines. It pupates on the gram pod surface or even in the burrow of the infested pod ; the pupa is also fringed with short hairs and spines and is often liable to be mistaken for the larva. The moth is a slender insect with the wings arranged in plumes (characteristic of the moths of this family *Pterophoridae*).

Control measures.—The methods of control which can be suggested against this insect are the same as for the gram caterpillar above.

THE GRAM POD FLY (*Fig.* 136).—(*Agromyza obtusa*, M.)—Unlike the above two pests this insect is a fly maggot but the nature of the injury done to the crop is more or less similar. The tiny maggot burrows into the seed and damages the same. The insect is occasionally bad in parts of the Ceded Districts, Mysore, etc.

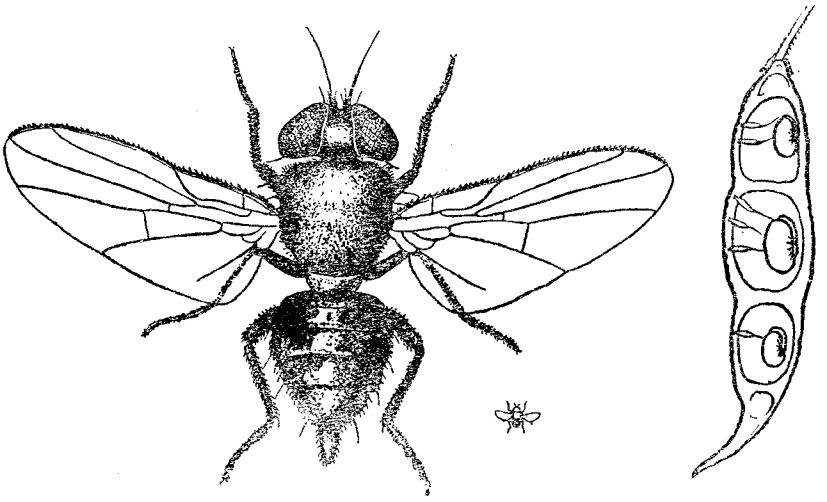


FIG. 136.—THE REDGRAM POD FLY.
(*Agromyza obtusa*, M.)
Fly and attacked pod.

[*From S.S.I.*]

Life history and habits.—The adult female fly thrusts minute eggs into the tissue of the shell of a tender pod and the hatching maggot enters the seed and feeds on the seed inside the pod. Though the whole seed is not eaten up by the maggot the partial damage caused spoils the seed and the latter also becomes subject to bacterial and fungoid diseases.

Control measures.—Only preventive measures are possible.

HAIRY CATERPILLARS.—Two species of hairy caterpillars are occasionally found attacking redgram though they very rarely cause serious harm. These are the well-known red hairy caterpillar (*Amsacta albistriga*, W.) noted under cholam and a species of tussock caterpillar (*Euproctis fraterna*, M.) The caterpillars are leaf eaters.

Tussock caterpillar (*Euproctis fraterna*, M. *Fig.* 90–9)—*Life history and habits.*—The life history of the red hairy caterpillar has already been described under cholam. In the case of the tussock caterpillar the parent moth lays batches of eggs on the leaves generally on the under surface and these batches are covered with

hairs deposited by the parent. The larvae which hatch out are long and slender and covered with hairs. These feed on the plant surface in groups gregariously and gradually grow to an inch and a half in length. The full grown larva is dark, reddish brown ; in addition to a covering of hairy tufts all over the body, it has a pair of long tufts directed forwards on either side of the head and a single elongated tuft directed backwards from the anal segment (hence known as *tussock* caterpillar). The caterpillar pupates in a thin cocoon of silk and hairs on the plant itself. The moth is medium sized and has orange yellow wings with light wavy markings.

Control measures.—The conspicuous eggmasses and the gregarious habits of the young larvae offer easy facilities to check the pest by collecting and destroying the eggmasses and the gregarious caterpillars by clipping the leaves on which they are found. In very bad infestations, application of a stomach poison can also be adopted.

MINOR INSECTS AFFECTING REDGRAM.—A number of other insects besides the important ones noted above are occasionally found on redgram but very rarely have they been found to be serious. The following are among these :—

Biting Insects.

(1) *Leaf and shoot folder* (*Eucosma critica*, M.).—A short pale yellowish caterpillar which remains feeding inside a fold or web of the top shoot leaves. The moth is a small dark brown creature.

(2) *Leaf roller* (*Gracillaria soyella*, D.)—A very slender greenish caterpillar which rolls the leaf tip ; it is hardly a pest. The moth is a very small brown creature.

(3) *The crab caterpillar* (*Stauropus alternus*, W.).—A curious looking greyish brown caterpillar with elongate limbs and anal claspers ; the moth is a fairly stout and grey brown insect with wavy markings on the forewing (fig. 137). It has occasionally been noted on tamarind, tea, etc.

(4) A looper caterpillar (*Pingasa ruginaria*, G.) is sometimes noted on redgram in parts of Malabar.

(5) *The blue butterfly* [*Lampydes boeticus*. L. (fig. 146)].—The short pale green flattish caterpillar occasionally feeds on the leaf, flowers and pods.

(6) *The orange banded blister beetle* (*Zonabris pustulata*, T.). —The common blister beetle found feeding on the flowers and shoots of many plants, especially those with yellow and red flowers (fig. 138).

(7) *Leaf weevils* (*Myllocerus* spp. and the large grey weevil *Episomus lacerta*, F., fig. 152).

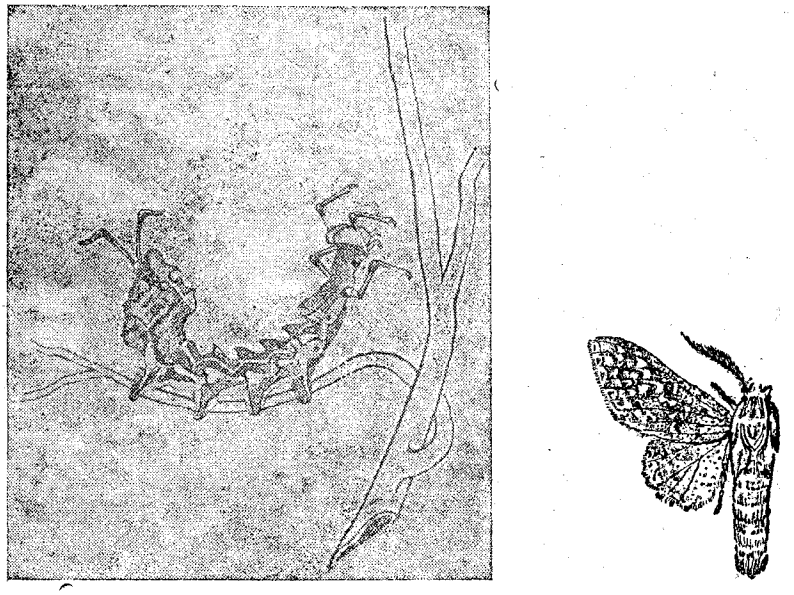


FIG. 137.—THE CRAB CATERPILLAR AND MOTH.
(*Stauropus alternus, W.*)

[*From S.S.I.*]

(8) *The bud weevil* (*Ceuthorrhynchus asperulus*, F.) breeding inside the tender buds and preventing pod formation. This is a small greenish brown weevil found so far only in the Northern Circars and Coimbatore and never as a serious pest (fig. 139).

(9) *The leaf cutter bees* (*Megachile* spp.) are occasionally found cutting and carrying away circular portions of tender leaves to line their nests.

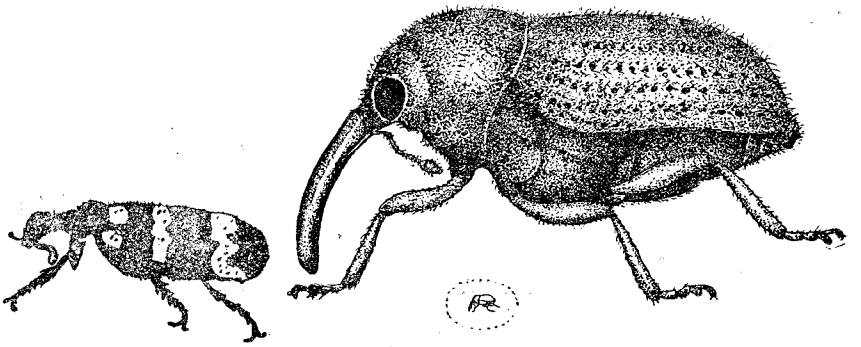


FIG. 138.—THE ORANGE BANDED BLISTER BEETLE.
(*Zonabris pustulata*, Th.)

FIG. 139.—THE REDGRAM BUD WEEVIL.
(*Ceuthorrhynchus asperulus*, F.)

[*From S.S.I.*]

[*From S.S.I.*]

(10) *The stem boring jewel beetle* (*Sphenoptera perotetti*, **G.**). —The pale white grub bores into the stem ; usually an important pest of groundnut (see page 213, fig. 163).

(11) *A species of pulse beetle* (*Bruchus theobromæ*, L., fig. 140) is also now and then found to feed on the pods in the field. Generally, pulse beetles are mostly pests in granaries and stores, but this one species has been noted as a field pest.

(12) A small dark buprestid beetle is noted in parts of Cochin.

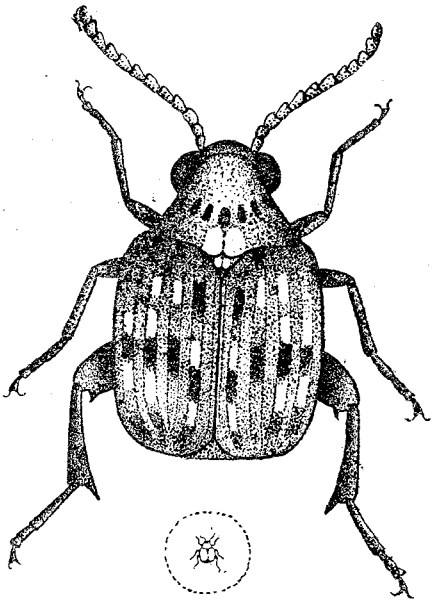


FIG. 140.—PULSE BEETLE ON REDGRAM.
(*Bruchus theobromae, L.*)

[*From S.S.I.*]

All these biting creatures can be easily controlled by mechanical means or by stomach insecticides in bad infestations.

Sucking Forms.

(1) *The pod bugs* (*Clavigralla horrens*, D., *and* C. *gibbosa*, S.).—These are active brown creatures almost as big as the rice bug and having the same habits (figs. 95 and 141). The bugs and the nymphs infest the pods and suck the juice.

(2) *The lablab bug* (*Coptosoma cribraria*, F., fig. 151).—This creature is often found in numbers attached to the tender leaves and shoots (see under *Dolichos*, page 199) ; another species *C. nazirœ* has been noted in the West Coast areas.

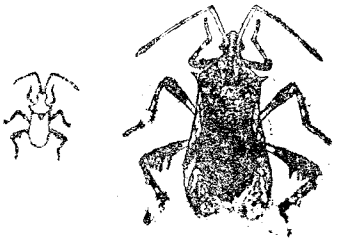


FIG. 141.—POD BUG OF PULSES.
(*Clavigralla horrens*, D.)

[*From S.S.I.*]

(3) *Scale insects* of different kinds of which two may be noted (*Ceroplastodes cajani*, M. *and Lecanium longulum*, D.)..The former (fig. 310), which is also found on *tulsi* secretes a waxy test often covering the shoots in masses of glistening white color and the latter is a brown elongated soft scale attached to the stem in numbers.

The active forms among these may be checked by use of hand nets and the scales by contact sprays.

BENGALGRAM.[1]

The only important pest of this crop is the gram caterpillar (*Heliothis armigera*, H.) noted under redgram. It is often very serious on bengalgram during the cold weather months and is found difficult to control unless promptly checked at the very initial stages of infestation. In areas where this pest is apprehended, the plants may be dusted with an arsenical insecticide as a preventive measure.

GREEN AND BLACKGRAMS.[2]

The younger stages of these crops often suffer from the attacks of plant lice (*Aphis*) ; as the plants grow they occasionally become subject to the attacks of hairy caterpillars, horned caterpillars and other minor leaf eating larvæ and weevils and later on, as the pods are formed one or two pod boring caterpillars also attack the crops. The chief pest is the red hairy caterpillar of cholam, groundnut, etc. (fig. 161); another species *Diacrisia obliqua*, W. is also found especially along the West Coast areas. A pod boring caterpillar (*Maruca testulalis*, G.) is an important pest of grams in South India ; the small pale green caterpillar bores into the ripening pods. Other pod boring caterpillars are those of the two butterflies *Euchrysops* and *Lampydes*, fig. 146.

The horned caterpillar (*Herse convolvuli*, L., fig. 91-1) is a long stout-built creature which often completely defoliates the plants. The seed-like shining eggs which are laid singly on the tender portions of the plant are conspicuous ; the caterpillars hatching out of these feed on the foliage and grow in a few days into stout

[1] Cicer arietinum. [2] Phaseolus spp.

creatures of about two to three inches in length, and with a conspicuous curved sharp spine on the dorsal surface of the anal segment. When full fed, the caterpillar pupates in an earthen cocoon under the soil. The adult is a stout-built moth with pale grey wings and transverse violet bands on the abdomen.

Control measures.—The pest can be easily checked by hand picking of eggs and the caterpillars. When it is too late to adopt such mechanical methods, stomach insecticides may be used according to the value of the crop. As a preventive against the pest appearing again on a following crop, the infested fields may be ploughed up and the underground pupæ exposed and destroyed.

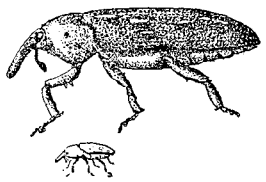


FIG. 142.—WEEVIL ON LEGUMES.
(*Alcidodes collaris*, P.)
[*From S.S.I.*]

The leaf infesting minor caterpillars include the green leaf caterpillar (*Anticarsia irrorata*, B.) the adult of which is a pale yellowish brown moth with a diagonal band on each wing; it has been found practically on all pulse crops (fig. 144).

Other leaf eaters are some weevils including two species of Alcidodes (*A. collaris*, P., fig. 142 and *A. fabricii*, F.) and a small ant like dark shining weevil (*Apion amplum*, F., fig. 262) which was noted on greengram in Coimbatore and which is sometimes found in numbers on blackgram in parts of Mysore and adjacent tracts. The greengram weevil (*Pachytychius mungonis*, M., fig. 143) is a specific pest of greengram in parts of the Ceded districts. It attacks the pods and often causes some damage. No effective remedy is known, but the collection and destruction of first attacked pods may give some relief.

HORSEGRAM.[1]

The important pests of this crop are hairy caterpillars of sorts including the notorious red hairy caterpillar of cholam and groundnut and the small gram leaf caterpillar (*Anticarsia irrorata*, B., fig. 144). Occasionally a green pod boring caterpillar (*Etiella zinckenella*, T., fig. 145) and the chrysanthemum caterpillar (*Lamprosema indicata* F., fig. 304) are found doing some damage. The moth of the former is a grey brown insect with a distinct pale white band along the front margin of the upper wings.

[1] Dolichos biflorus.

Cowpea.[1]

Insects affecting this plant are more or less similar to the gram pests noted above. These include plant lice (chiefly *Aphis laburni*, K.), blue butterflies, flower feeding blister beetle, the pod bugs of redgram and the leaf eater *Anticarsia irrorata*, B. (fig. 144); the caterpillars of the blue butterflies *Lampydes* and *Euchrysops* are common on all pulses (fig. 146). One of the pod bugs is a large dark brown insect with stout and curved hind legs (*Anoplocnemis*), fig. 147. There is, however, one specific fly pest of this crop which is fairly important, viz., the stem fly.

The Cowpea Stem Fly (*Agromyza phaseoli*, C., fig. 148).—This fly is sometimes a serious pest of cowpea. The damage is caused to the tender stem of the growing plant by the small pale yellowish boring maggot of this small blue-black fly, which in general appearance resembles a small house fly. It is similar to the redgram pod fly in general features but the larva is a stem boring maggot.

Life history and habits.—Eggs are thrust into the epidermis of the soft stem and the hatching larvæ burrow into the stem; this affects the stem, causing wilting and death of the plants in many cases. Pupation takes place in the larval burrow and many pupæ are often found in the same stem. Sometimes young plants suffer appreciably.

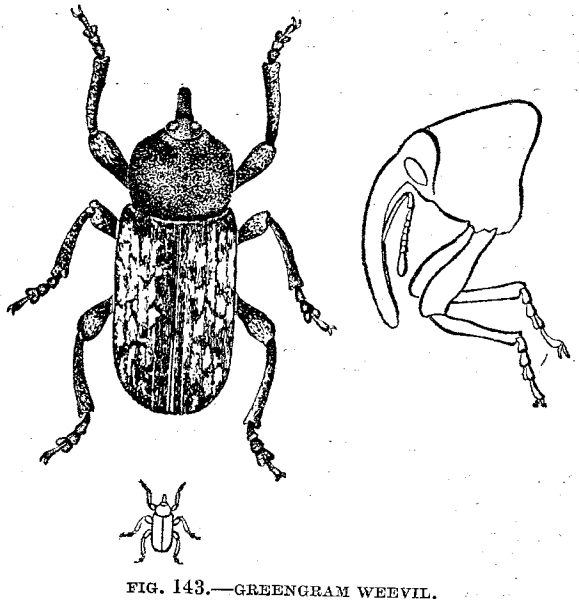


FIG. 143.—GREENGRAM WEEVIL.
(*Pachytychius mungonis*, *M.*)

[*From S.S.I.*]

[1] Vigna catjang.

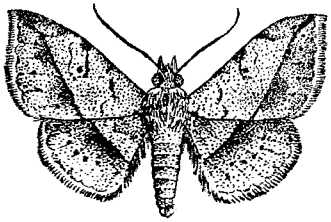


FIG. 144.—SMALL GRAM MOTH.
(*Anticarsia irrorata*, B.)
[*From S.S.I.*]

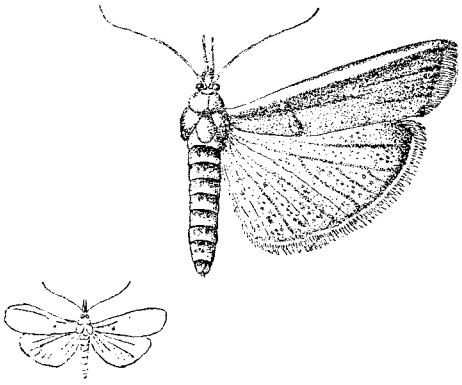


FIG. 145.—PULSE POD BORER MOTH.
(*Etiella zinckenella*, T.)
[*From S.S.I.*]

Control measures.—Only preventives are possible and even these become impracticable in cases of sudden and widespread infestations.

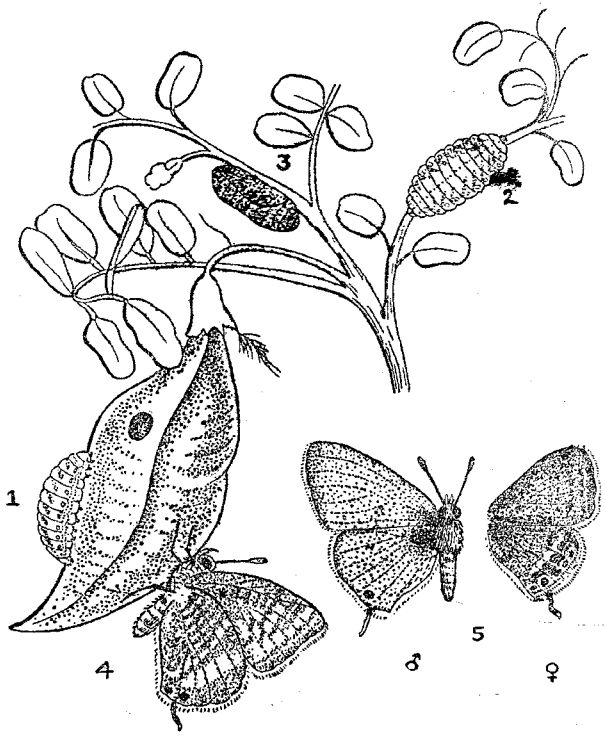


FIG. 146.—BLUE BUTTERFLY OF LEGUMES ; STAGES.
(*Lampydes bœticus*, L.)
[*From S.S.I.*]

1 & 2 Caterpillars. 3 Pupa. 4 & 5 Butterflies.

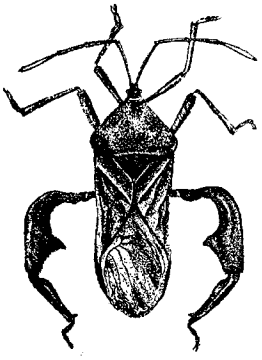


FIG. 147.—A LEGUME POD BUG.
(*Anoplocnemis phasiana*, F.)
[*From S.S.I.*]

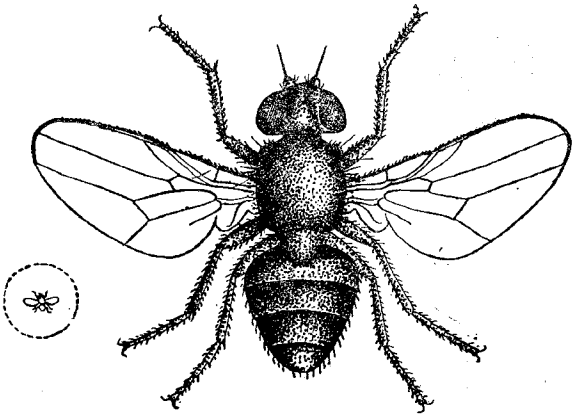


FIG. 148.—COWPEA STEM FLY.
(*Agromyza phaseoli*, C.)
[*From S.S.I.*]

The caterpillar of the moth (*Eublemma hemirhoda* W.,) attacking the pods and a longicorn beetle grub (*Oberea* sp.) boring into the stem have been noted in Travancore. A leaf eating syntomid caterpillar (*Amata passalis*, F.) has also been noted in that area as a minor pest.

A cow bug (*Anchon pilosum*, W.) has been recently noted by the author to injure cowpea and lablab in Malabar.

Species of blister beetles are often sporadic pests on cowpea and other pulses. One species (*Cantharis cetacea*) appeared as such in parts of the Northern Circars a few years ago.

Soy Bean.

This crop which is now being grown in different parts of the province has been found subject to the attacks of two insects, viz., the groundnut *surul* (*Stomopteryx*) and the stem boring longicorn beetle noted below. For details about the groundnut *surul* see under groundnut (page 209).

The soy bean stem borer beetle—(*Oberea brevis*, S., *Fig.* 149).—This insect has been found to attack the stems of soy bean plants and cause some appreciable damage. It is a small sized pale brown

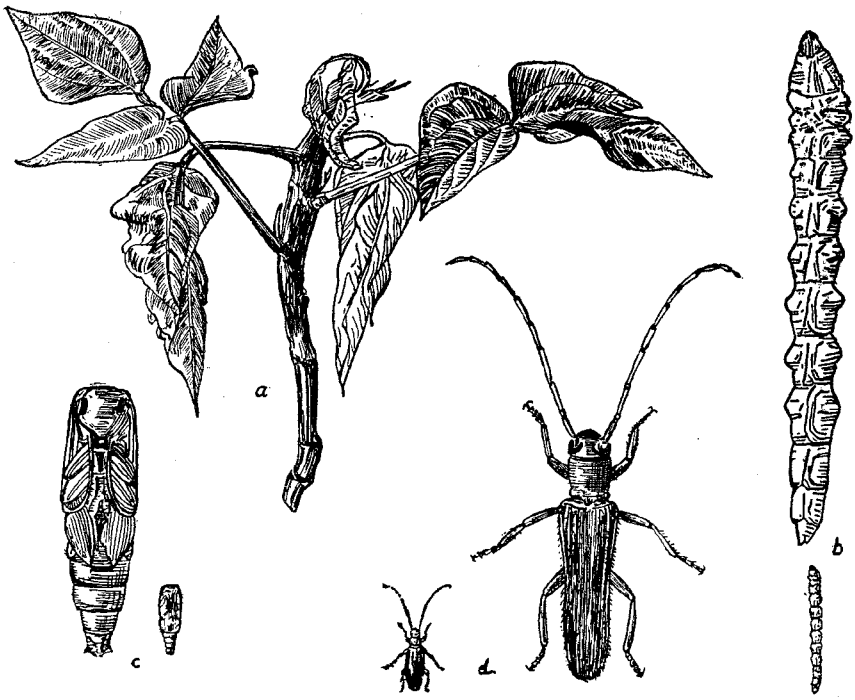


FIG. 149.—THE SOY BEAN STEM BORER.
(*Oberea brevis*, S.)
a Attacked stem.
b, *c* & *d* Larva, pupa and adult beetle.
[*From I.E's Rpt.* 1917–18]

longicorn beetle with the posterior margins of the upper wings banded in dark. The slender pale white grub of this creature works as a typical stem borer and in many cases the whole plant is killed. The progress of the pest has to be watched with the increase in area of soy beans.

Field and Garden Bean (*Dolichos lablab*).

Numerous insects are associated with this plant which is cultivated both as a field and a domestic vegetable crop. The more important of these insects which cause damage are plant lice, pod borer caterpillar, the lablab bug and the leaf weevil.

Plant lice.—In certain seasons the tender vines and shoots are found very badly infested by numerous colonies of plant lice (*Aphis craccivora*, K.) (fig. 150). But the pest can be checked easily by insecticidal methods and also by encouraging its natural enemies.

THE POD BORER CATERPILLAR (*Adisura atkinsoni*, M., fig. 203–1). The larva of this moth is a cylindrical brownish green caterpillar which has the habit of boring into the ripening lablab pods and feeding on the seeds, just like the gram caterpillar (*Heliothis*). During the cold weather field beans suffer rather heavily from this post during certain years in the Northern Circars and the Coimbatore tract.

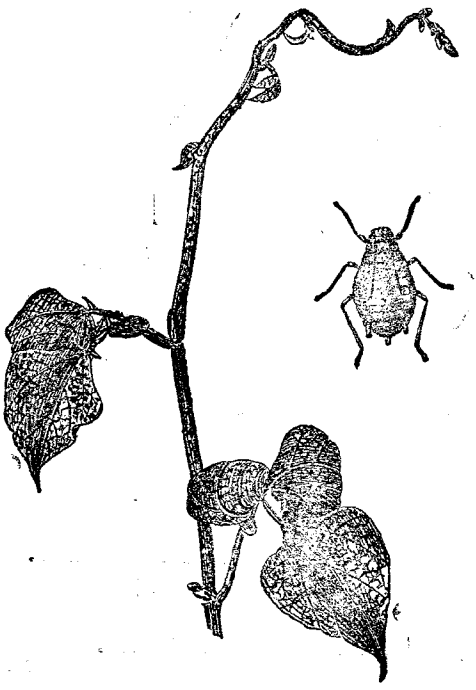


FIG. 150.—THE LAB LAB APHIS.
(*Aphis craccivora*, K.)

Life history and habits.—Small spherical eggs are laid singly by the moth on the tender pods or buds. The caterpillars hatching out of these first feed on the pod surface and gradually enter the pod; they feed on the seeds and make the pod empty. The larva attains a length of about an inch and pupates in the soil. The moth is a pale yellowish brown insect, but smaller in size than the gram moth. It is also found sometimes on redgram.

Control measures.—Preventive and other measures similar to those against gram caterpillar can be adopted.

THE LABLAB BUG—(*Coptosoma cribraria*, F.) (*Fig.* 151).—This is an insect very common and familiar to most gardeners both from its small oval shape and the peculiar buggy stink associated with it. Hundreds of these are often found attached to the tender vines sucking up the plant sap and allowing the vines and shoots to fade.

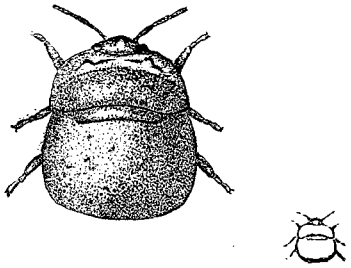


FIG. 151.—THE LAB LAB COPTOSOMA.
(*Coptosoma cribraria*, Fb.)

Life history and habits.—Very small ashy grey eggs which are beautifully sculptured are laid in rows, often in parallel rows, on the tender parts of the plant ; these hatch into active nymphs which gradually attain the adult winged stage after the usual moults. As stated before, it is also found sometimes on redgram and other plants like Indigo, Agathi, Pongamia, etc.

Control measures.—The most economical and practical remedy is that of collecting the bugs in hand nets and destroying the lot in vessels containing water mixed with kerosene. The eggs can also be easily picked off and destroyed. B.H.C. either in the form of dust or spray has been found to effectively control this pest .

THE LEAF WEEVIL (*Episomus lacerta*, F., *Fig.* 152).—This large sized grey weevil is a specific pest of field beans although occasionally found on other leguminous crops like redgram, etc. In bad infestations whole fields are completely defoliated by these voracious beetles.

Control measures.—This insect can be easily hand picked and destroyed ; in serious cases the plants may also be sprayed with a stomach insecticide.

Other insects of minor importance feeding on lab lab include (1) the leaf miner caterpillar (*Acrocercops coerulea*, M.), a very small pinkish caterpillar boring into the leaf tissue and causing pale white blisters on the leaf surface; this damage is sometimes serious in Malabar and adjacent areas. The adult insect is a very small moth. (2) The lab lab sphinx (*Acherontia styx*, W.) belonging to the same group as the horned caterpillar of gram referred

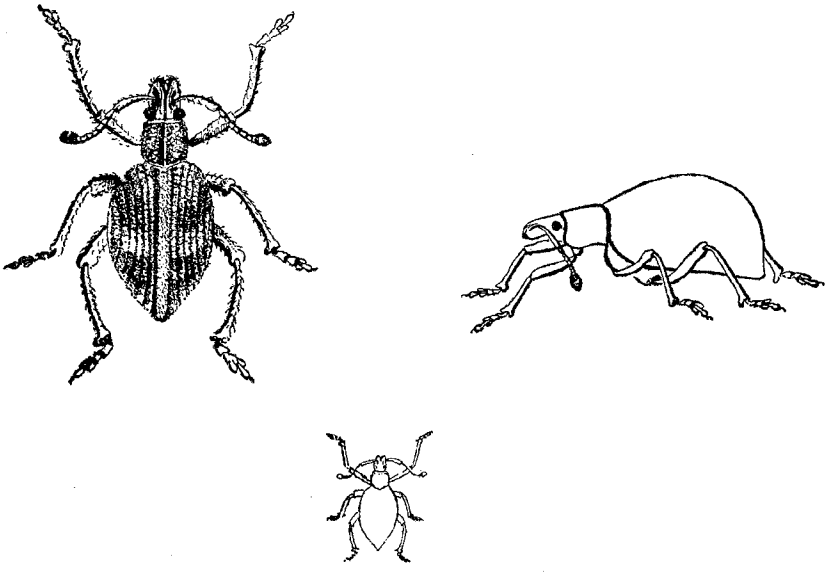


FIG. 152.—THE BEAN LEAF WEEVIL.
(*Episomus lacerta*, F.)

[*From S.S.I.*]

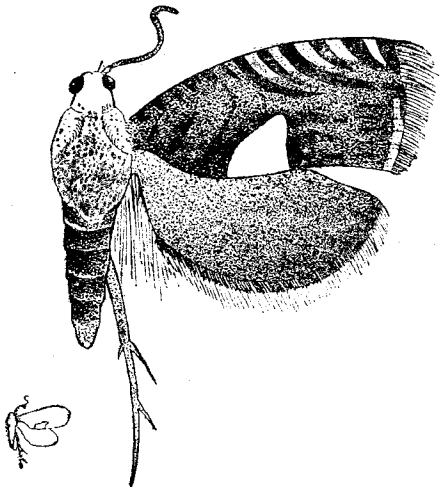


FIG. 153.—LAB LAB SHOOT BORER MOTH.
(*Enarmonia torodelta*, M.)

[*From S.S.I.*]

to above. It is a stout greenish caterpillar with yellowish lateral bands on both sides of the body and a conspicuous curved yellowish dorsal spine on the last segment. The life history is exactly like the gram sphinx, but the pupa in this case has not got the jug handle proboscis sheath of the gram sphinx (see fig. 91-3). The insect can be easily controlled by hand picking. (3) The shoot borer caterpillar (*Enarmonia torodelta*, M., fig. 153); this is the very small larva of a small moth boring into the distal tender top shoots and allowing them to fade and droop; is a minor pest which can be checked by clipping and destroying first attacked shoots. (4) Stem gall weevil (*Alcidodes pictus*, B.); the grub of this small dark weevil burrows into the main vines and causes peculiar galls. It is a pest often found in old vines left after the season; two other weevils with the same habit noted by the author are *Colobodes dolichotis*, M., in Coimbatore and the other *Desmidophorus* sp. in the Northern Circars. (5) Stem boring chrysomelid (*Sagra nigrita*, O.)—an insect with habits similar to the gall weevil; the adult is, however, not a weevil but a medium sized glistening green beetle with the hind legs extraordinarily swollen. It has so far been noted only in Mysore in South India. (6) Leaf hispid beetle (*Platypria hystrix*, F., fig. 154)—a small oval spiny insect, like the rice hispa, feeding on

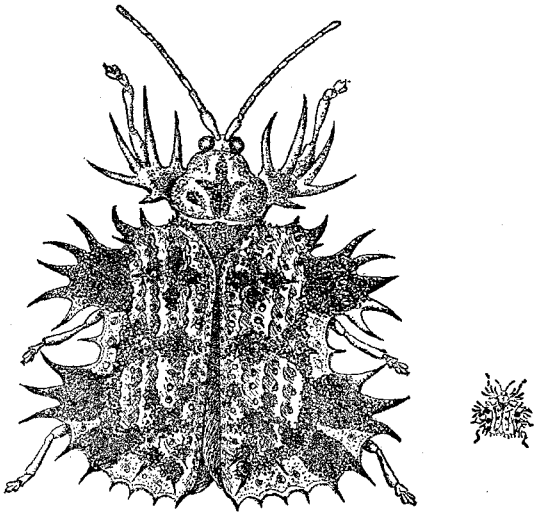


FIG. 154.—LABLAB SPINY BEETLE.
(*Platypria hystrix*, F.)

[*From S.S.I.*]

the leaves. (7) A small pulse beetle (*Bruchus 4-maculatus*, F.), is often found feeding on lablab and redgram in the fields in Coimbatore. (8) A few species of thrips (especially *Ayyaria choetophora, K., and Toeniothrips distalis, K.*). Numbers of these minute dark

creatures swarm inside flowers, and in bad cases, prevent pod formation. (9) A dark brown active pod bug (*Riptortus pedestris*, F.); this is also found on cowpea and other pulses—fig. 155. (10) The two hairy caterpillars (*Diacrisia obliqua*, W. and *Pericallia ricini*, F.) are often found as common pests in parts of the West Coast especially along the foot-hills of the Western Ghats.

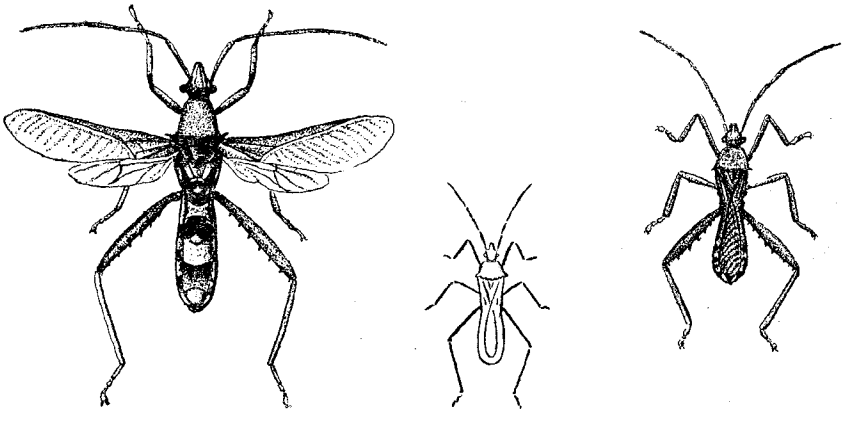


FIG. 155.—LAB-LAB POD BUG.
(*Riptortus pedestris*, F.)

[*From S.S.I.*]

OIL-SEED PLANTS.

The important oil-seed plants grown in South India include gingelly, groundnut, castor and the coconut palm. The minor ones include Safflower, Linseed, Bassia, Calophyllum, etc.

GINGELLY.*

THE LEAF AND POD CATERPILLAR (*Antigastra catalaunalis*, D., *Fig.* 156).—This insect is the most important pest of the crop and is found in all the gingelly tracts of the province. The caterpillar is a small greenish cylindrical creature with dark tubercles on the body surface. It feeds on the tender foliage, webs the top leaves and also bores into the pods and shoots. It is sometimes found as a serious pest in parts of South Arcot, Malabar and Northern Circars.

Life history and habits.—Single shining eggs are laid on the tender portions of the plant; the young larva feeds on the tender leaves and later on as it grows it bores into the shoots, folds and webs the leaves and attacks the ripening seed pods. The caterpillar when full fed is about two-thirds of an inch in length and has a pale green colour with the head black; the body is fringed with short black setæ which gives it a black spotted appearance. The pupa is pale whitish green and is enclosed in a transparent pale white silken cocoon. The adult insect is a small brown moth with pale yellowish brown wings. It has not been found to feed on any other plant till now.

* *Sesamum indicum*

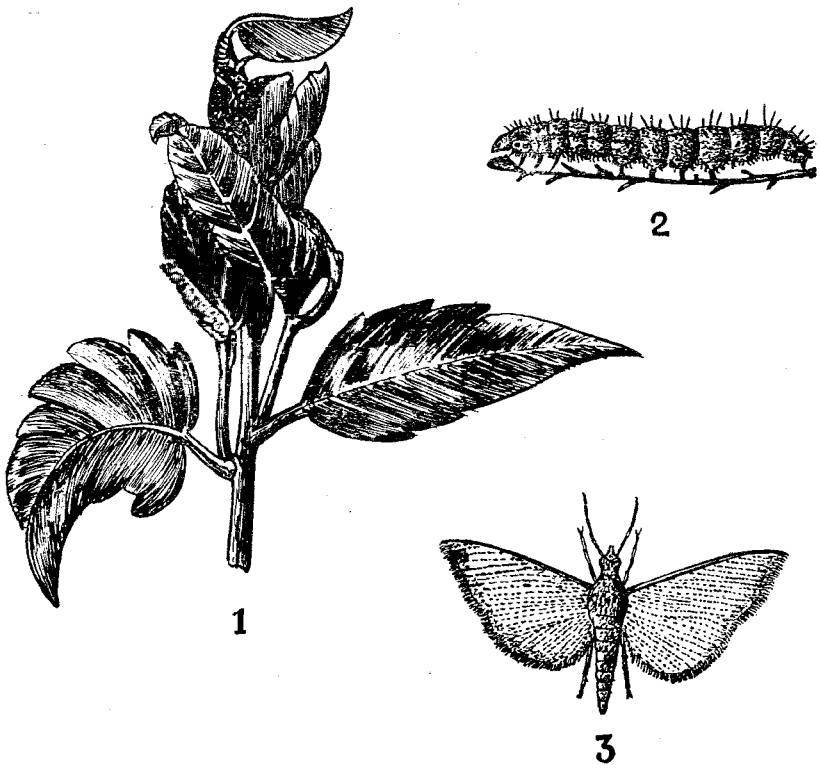


FIG. 156.—THE GINGELLY SHOOT AND POD BORER.
(*Antigastra catalaunalis*, D.)
1 Attacked shoot. 2 Caterpillar. 3 Moth.

Control measures.—Difficult to deal with in a bad infestation. The affected leaves and shoots may be hand-picked and destroyed as a preventive measure. Spraying with insecticides except in valuable experimental plots will neither be very effective nor economic, because of the curious feeding habits of the insect.

THE SPHINX CATERPILLAR (*Acherontia styx*, W., *Fig.* 91-*III*).—Though this insect has already been noted under lab lab it is known as the gingelly (Til) sphinx in Northern India since it is very often found on gingelly also. For life history and habits see under *Dolichos* p. 200.

The semi-looper caterpillar (*Plusia signata*) has been noted occasionally on this crop in parts of Cochin.

THE GINGELLY GALL FLY (*Asphondylia sesami*, F., *Fig.* 157).—The small whitish maggot of this fly feeds on the contents of the young flower buds and the irritation so caused causes formation of malformed gall-like buds which do not develop into seed capsules; these latter gradually fade and drop. It is a specific pest of gingelly in different parts of South India. The adult insect is a mosquito-like fly. The eggs are laid in the flowers; the maggots feed on the

contents of the flowers, cause the galls and pupate inside the same to emerge as adult flies. The pest is difficult to control in bad infestations. Clipping of the galls and picking off and burning the shed buds may help as prophylactic measures.

SAP SUCKING INSECTS (*Eusarcocoris ventralis*, W., fig. 158 *and Nysius inconspicuous*, D.).—These are two of the more important active plant bugs often found sucking the sap from the tender parts of growing gingelly. Sometimes hundreds of these fly about like mosquitoes when the plants are disturbed. The eggs and all the stages of the bugs can be noticed on the infested plants. The use of nets and sticky boards will be found practicable and effective against these bugs.

A stem-boring longicorn (*Oberea* sp.) is noted as a minor pest of gingelly in the Ceded districts.

1 2

FIG. 157.—THE GINGELLY GALL FLY.
(*Asphondylia sesami*, F.)
1 Damaged plant shoot.
2 Gall fly.

[*From S.S.I.*]

CASTOR.*

The important pests of the castor oil plant include about a half a dozen leaf-eating caterpillars and two or three bugs.

THE CASTOR SEMI-LOOPER (*Achœa janata*, L.).—This is a specific pest of castor found all over the province. The long smooth greyish brown caterpillar has the first pair of prolegs reduced and as such is a semi-looper (fig. 159–4). It is a leaf-eater and in certain

* Ricinus communis.

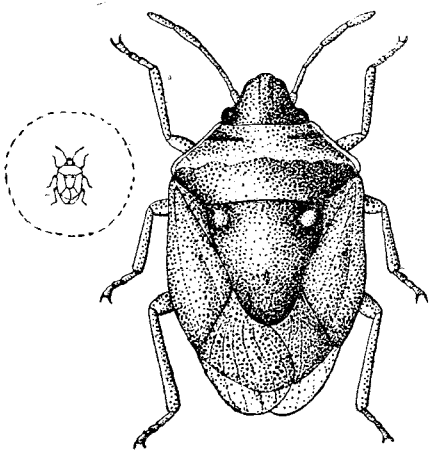


FIG. 158.—GINGELLY POD BUG.
(*Eusarcocoris ventralis*, W.)

[*From S.S.I.*]

seasons considerable damage is caused in some tracts, especially in parts of the Ceded Districts. In badly infested fields the pest completely defoliates the plants and leaves only the leaf ribs and stems. A closely allied moth (*Parallela algira*, L.) is sometimes found in company with the castor semilooper.

Life history and habits.—Single greenish brown eggs are laid by the mother moth on the tender shoots and leaves. These hatch in about three or four days into caterpillars which feed on the foliage and grow in size. When full grown the caterpillar is about $2\frac{1}{2}$ inches in length smooth and elongated and has a dull greyish brown color ; this coloring is variable with brownish or pale white stripes along the body. Pupation takes place either in the soil or in folds of leaves. One life cycle occupies about a month. The adult insect is a stout greyish brown moth with black blotches on the hind wings. Besides castor it has been occasionally found to feed on the pomegranate plant and a few euphorbiaceous weeds. The caterpillar is often subject to the attacks of a specific hymenopterous parasite (*Microplitis ophiusae*, R., fig. 69) which effectively keeps it in check during certain seasons ; the pupal cocoon of this wasp is seen under the tail of the host. This insect has been noted also on *Euphorbia, Sapium, Albizzea*, etc.

Control measures.—Hand picking and destruction of the larvae which are easily found on the plants. In bad infestations stomach insecticides may be applied either as a spray or as a dust.

THE TOBACCO CATERPILLAR—(*Prodenia litura*, F., figs. 159–3, 83–2 and 281).—This insect is one of the cut-worms and feeds on various cultivated plants of which tobacco is the most important hence its name. On castor it occasionally appears as a serious pest in the same way as the semilooper and causes damage. (For life history, etc., see under *Tobacco*).

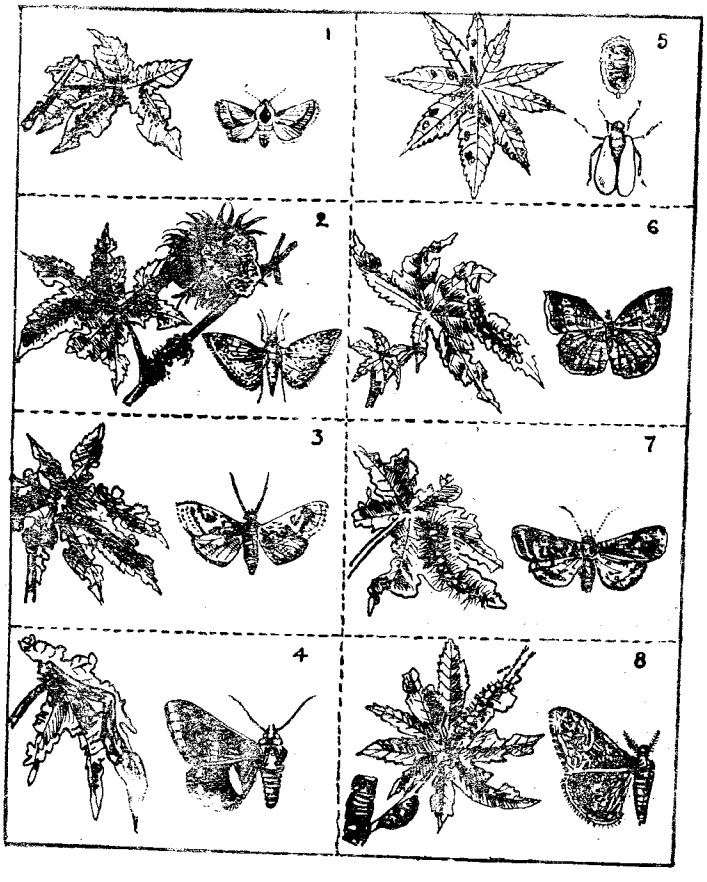


FIG. 159.—SOME PESTS OF CASTOR IN SOUTH INDIA.

1 Castor slug (*Parasa*).
2 Capsule borer (*Dichocrocis*).
3 Leaf noctuid (*Prodenia*).
4 Semilooper (*Achoea*).
5 Mealy wing (*Trialeurodes*).
6 Butterfly (*Ergolis*).
7 Black hairy caterpillar (*Pericallia*).
8 Tussock moth (*Notolopus*).

THE CASTOR SLUG [*Latoia* (*Parasa*) *lepida*, C..]—This caterpillar has a green soft hairy body covered with rows of spines and tubercles [figs. 159 (1) and 223]. It causes the same damage to the plants as the tobacco caterpillar and the semilooper.

Life history and habits.—Batches of flat scaly eggs are laid on the tender parts of the plant and the caterpillars hatching out of them feed on the tender foliage gregariously. A full grown caterpillar is flattish, short and stout and moves like a slug. It grows to about an inch in length and has an apple green body color with pale white or bluish stripes along the body. The body is covered with rows of tubercles from which tufts of spines and hairs are given out; these latter are irritating to the touch and it causes serious itching when the caterpillar is handled. The caterpillar pupates inside a thick shell like oval grey cocoon generally attached to the stem of the plant; even these cocoons are covered with irritating hairs and spinelets. Sometimes hundreds of these cocoons are found attached in batches to the surface of the stem and main branches. The adult insect is a stout short moth with green wings and with a prominent dark patch at the base of each forewing.

Besides castor, the insect is occasionally found feeding on young mango leaves, pomegranate plants, coconut and palmyra palms, woodapple and a few other plants.

Control measures.—The gregarious habit of the larva makes it easy to employ hand picking and destruction of the first infested leaves. In bad infestations on valuable areas a stomach insecticide may be employed D.D.T. and B.H.C. dusts give effective control of the caterpillars. As a check against the future multiplication of the pest the cocoons on the plant may be crushed and the emergence of moths prevented. Parasites are occasionally found attacking the larvae; inside the cocoons of this pest a predatory caterpillar (*Phycita dentilinella*, H.) is occasionally seen destroying the pupa.

Another slug caterpillar (*Altha nivea*, W.) the moth of which is pure white in color is occasionally seen on castor in parts of the Ceded Districts.

HAIRY CATERPILLARS.—Three or more species of hairy caterpillars attack castor. These include the three or four tussock moths (*Euproctis fraterna*, M., *Porthesia scintillans*, W., *Notolopus postica*, W., and *Dasychira mendosa*, H.) and a black hairy caterpillar (*Pericallia ricini*, F), (figs. 175, 186 and 159). These are generally of minor importance though during certain years they appear as sporadic pests.

Life history and habits.—The life histories and habits of these insects are more or less similar. Eggs are laid in batches on the leaf surface and the caterpillars feed on the foliage and pupation generally takes place in thin silken and hairy cocoons in folds of leaves. The moths are, of course, different in colour, and in the case of one of them (*Notolopus*) the female has practically no wings, fig. 19.

	Caterpillar.	Moth.
1 Euproctis fraterna ..	Dark reddish brown ..	With yellow wings.
2 P. scintillans ..	Dark reddish brown with a median dorsal longitudinal yellow stripe.	Do.
3 Olene mendosa ..	Grey brown	Straw colored wings.
4 Notolopus postica	Brownish hairy	Female wingless. Male with grey brown wings.
5 Pericallia ricini ..	Black	With grey upper wings and red spotted lower wings and abdomen.

All these are occasionally found subject to the attacks of both hymenopterous and fly parasites.

Control measures.—Collection of egg masses and clipping and destruction of leaves on which the caterpillars feed gregariously are the most effective and economic measures. Application of contact sprays at the gregarious stage also controls the pests.

THE CASTOR SHOOT AND SEED BORER—(*Dichocrocis punctiferalis*, G., fig. 159-2).—This is short dark brown caterpillar which bores into the shoots and seed capsules and is sometimes more serious and difficult to check than the leaf eating caterpillars. The external indications of the presence of this pest are the existence of frassy matter at the bored shoots and the webbed condition of the seed capsules covered with dark excrementaceous matter. Several seeds are often found webbed together in this manner. The insect is found all over the province.

Life history and habits.—Eggs are laid on the tender parts of the plant and the caterpillars bore into the shoots in younger plants and enter the seed capsules in older ones. The full grown larva reaches an inch to an inch and a quarter in length and has a brownish to reddish brown color. The body surface is fringed with short tubercles, each giving rise to a short hair. The head is reddish. It pupates in a silken cocoon either inside the burrowed stem or the web or even inside a hollowed out seed capsule. The moth is a medium sized brownish yellow one with a number of dark spots on the wings. Besides castor which forms its chief food plant the insect has been noted as a fairly important pest on turmeric and ginger and as a minor pest of guava, cardamom, etc. Outside the province it has been noted on Peaches, Cocao, mango flowers, etc.

Control measures.—The prompt collection and destruction of attacked shoots and capsules which are conspicuous will be effective. Stray plants found attacked during the off-season may also be attended to as a preventive.

MINOR PESTS OF CASTOR.—The minor pests of castor include (1) the castor butterfly (*Ergolis merione*, C., fig. 159–6) a snuff colored butterfly the greenish spiny caterpillar of which feeds

on the leaves, (2) a small grey brown flea beetle (*Hermacophaga ruficollis*, L.) which bites small holes on the leaf, (3) a small green leaf hopper (*Empoasca flavescens*, F.) fig. 160, which sometimes appears in swarms and sucks the plant sap., (4) the well-known green plant bug (*Nezara viridula*, L., fig. 125), (5) the castor mealy wing (*Trialeurodes ricini*, M., fig. 159–5) a small cream white insect which is found in colonies in various stages on the lower surface of the foliage of fairly grown up plants, (6) the small shot hole borer beetle (*Xyleborus fornicatus*, E., fig. 297) which is only rarely found attacking the stems of old plants in parts of Mysore, (7) leaf weevils chiefly (*Myllocerus viridanus*), (8) and a small pyralid caterpillar (*Myelois pectinicornella*, H.) is sometimes found breeding in ripening capsules in parts of Northern Circars, (9) An Eucosmid caterpillar (*Lobesia aelopa*, H) is sometimes found on castor seed pods in Coimbatore, (10) The bagworm, *Clania* (fig. 32) is also occasionally found on castor.

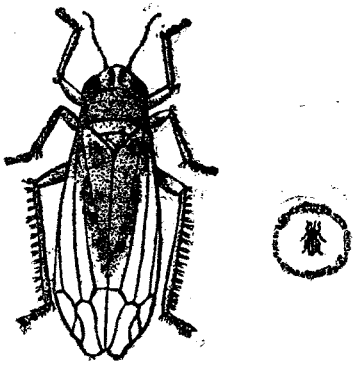


FIG. 160.—CASTOR LEAF HOPPER BUG.
(*Empoasca flavescens*, Fb.)

[*From S.S.I.*]

GROUNDNUT.*

The important insect pests of this crop in South India are the Red hairy caterpillar (*Amsacta albistrigam*) of cholam, the Surul puchi—a small leaf mining caterpillar (*Stomopteryx subsecivella*, M.) and the Verpuchi (*Sphenoptera perotetti*, G.) a stem boring beetle.

The Red Hairy caterpillar though found on other crops like millets, etc., is a very serious pest of groundnut in the province. Its seasonal life history on this crop is shown in fig. 161.

THE GROUNDNUT "SURUL" PUCHI—(*Stomopteryx subsecivella*, M., fig. 162).—This is a specific pest of groundnut all over South India. The leaf miner is a small dark headed greenish caterpillar which mines into the young leaves and also folds and brings together adjacent leaves and feeds on the leaf tissue—hence known as *surul* or *mudu* puchi. In parts of South Arcot this is

* *Arachis hypogoea.*

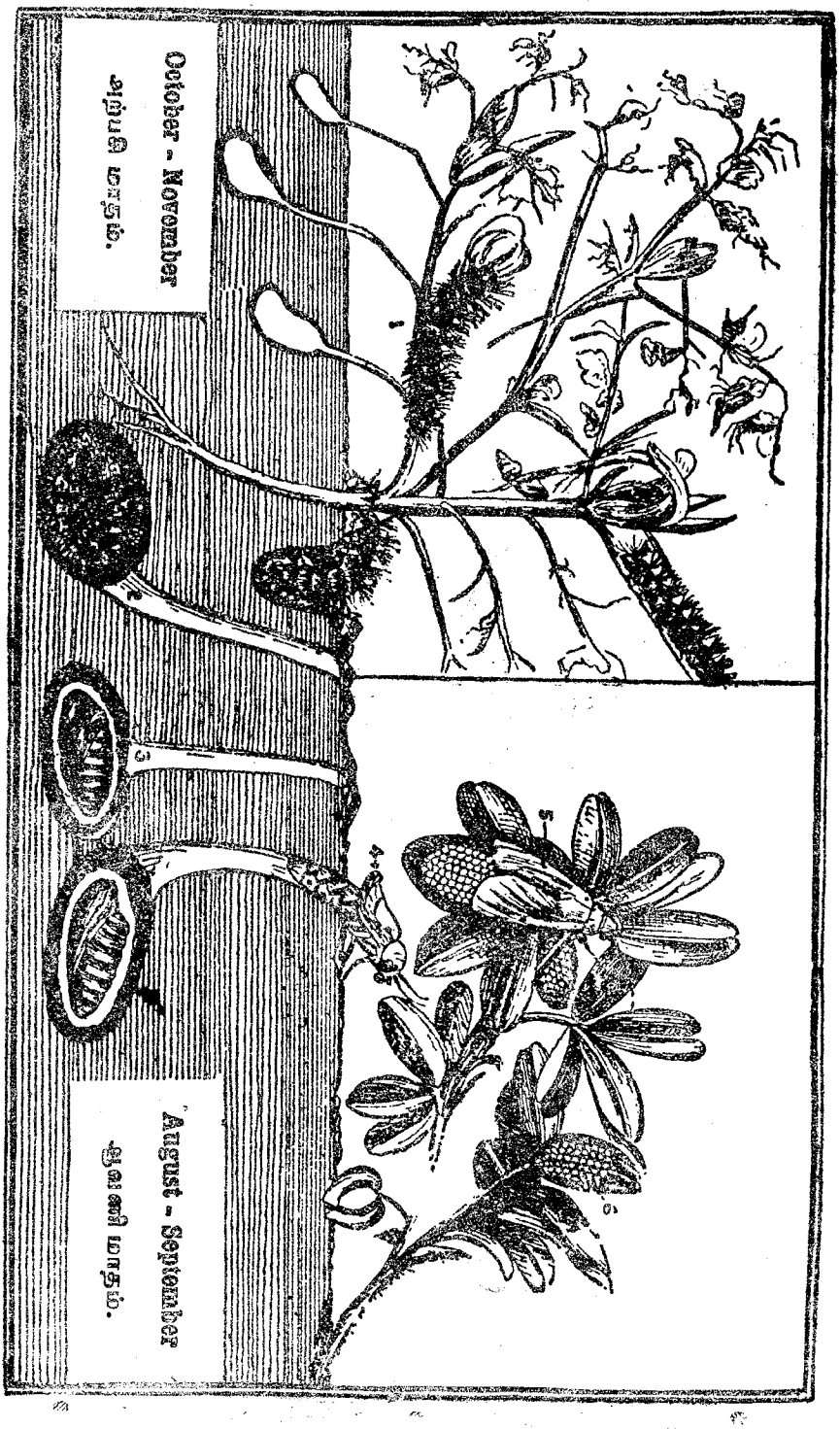


FIG. 161.—SEASONAL BEHAVIOUR OF THE RED HAIRY CATERPILLAR (*Amsacta albistriga*, W.)

often a very serious pest, and attacks both rain-fed and irrigated crops. Badly infested fields show the plants with many of the leaves dried up as though affected by fire.

Life history and habits.—Minute shining beautifully sculptured eggs are laid singly on the tender shoots. The young caterpillar first mines into a tender leaf—the mined portion of the leaf appearing as a pale blotch on the leaf surface. As it grows it brings together adjacent leaves and remains feeding inside the fold. A full fed caterpillar is one-fourth of an inch long, smooth and uniform green in colour with the head and prothorax dark. The small reddish brown pupa is found in the leaf fold or in the mines of infested leaves. The adult is a very small dark brown moth with a conspicuous small pale white dot at the front margin of each upper wing (fig. 162). The caterpillar is attacked by a few hymenopterous parasities but these latter are rarely found effective as natural checks. The insect has been noted also on soy bean, and to a certain extent on redgram. The wild shrub *Psoralea corylifolia* is another alternate host plant of this insect.

Control measures.—The moth has great attraction for lights and as such light traps can be put up during the early stages of the plant in areas which are notoriously infested every season. Other measures are of doubtful utility. Recently D.D.T. 5 per cent dust has been found to give a certain amount of relief.

THE GROUNDNUT VERPUCHI (*Fig.* 163)—(*Sphenoptera perotetti*, G.).—This insect belongs to the group of what are known as jewe beetles and has a shining dark brown colour. The larva of this beetle burrows into the stem of the groundnut plant close to the soil surface and kills the same. It is found in all the groundnut tracts of the province. Infested fields show dead and dying plants; when such plants are pulled up and examined, the pale whitish grub, its pupa, or signs of borer attack canbe seen in the stem.

Life history and habits.—Eggs are laid on the main stem of the plant; these hatch into pale whitish grubs known a, 'flatheaded grubs; which enter the stem and grow by feeding inside the same A full grown grub measures an inch and a half in length; it is sordid white in colour with the anterior region flattened. It gradually bores down the stem and pupates in the larval burrow emerging as the adult beetle in about ten days.

Control measures.—The preventive measure of pulling out and destroying first attacked plants is the only feasible method. Beetles when found in the fileds may be collected and destroyed to prevent egg laying.

MINOR PESTS OF GROUNDNUT.—Other insects affecting grounh nut include (1) the gram caterpillar (*Heliothis armigera*, F) whic occasionally causes som appreciable damage as a leaf and shoot feeder, (2) one or two pecies of semilooper caterpillars (*Plusic*

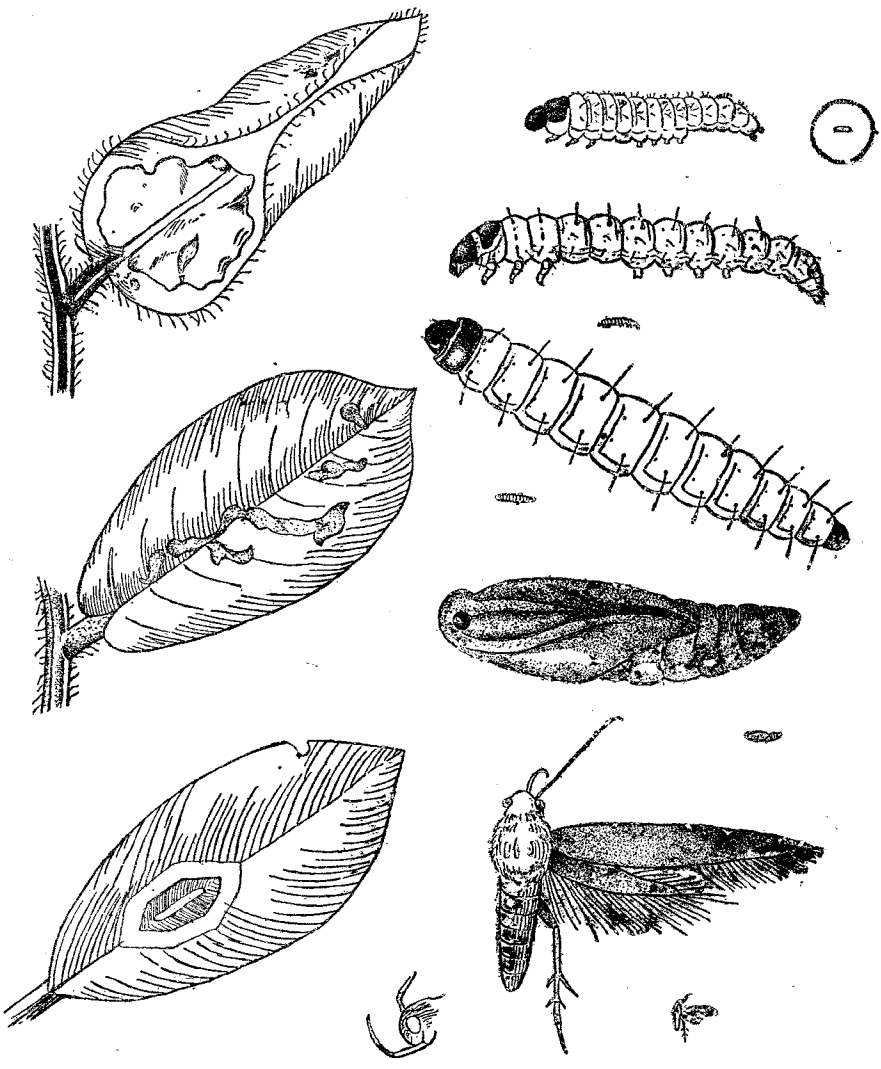


FIG. 162.—THE GROUNDNUT LEAF MINER—SURUL PUCHI.
(*Stomopteryx subsecivella* Z.)
Damage done by the insect and its stages.

[*From S.S.I.*]

spp., fig. 164) feeding on the leaves, (3) leaf weevils (chiefly green species of *Myllocerus*), (4) leaf eating grasshoppers (*Chrotogonus* and *Orthacris*), (5) flower beetles including a chafer (*Oxycetonia versicolor*, F., fig. 92) and the orange banded blister beetle (*Zonabris pustulata*, T., fig. 138), (6) Thrips (*Heliothrips indicus*, B.), a small dark species often found in numbers on the shoots and causing some injury often known as '*Thamara novu*, in some parts,

and (7) the pod sucking bug (*Aphanus sordidus*, F. fig. 165); this is an active brown bug appearing in numbers at harvest time and sucking the oily matter from the freshly harvested pods. This insect is also noted to behave in the same way with the fresh seeds of cumbu, tenai, etc. It is occasionally serious in some areas.

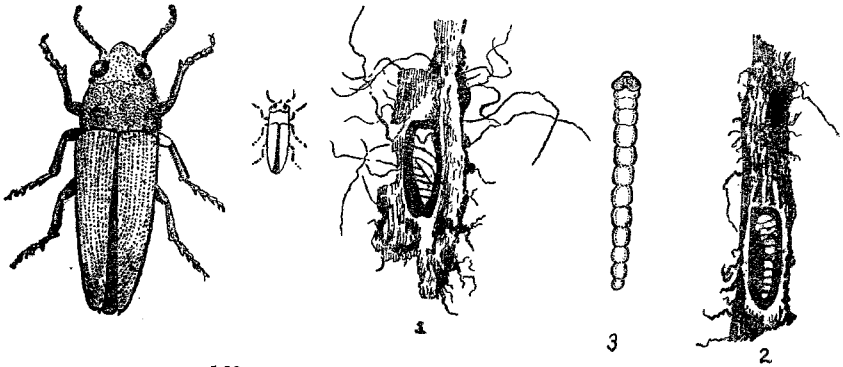


FIG. 163.—THE GROUNDNUT VERUPUCHI.
(*Sphenoptera perotetti*, G.)
1. The beetle. 2 & 3. Grub and pupa in stem
[*From S.S.I.*]

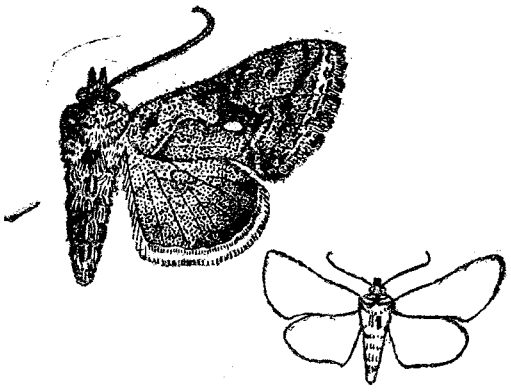


FIG. 164.—MOTH OF SEMILOOPER ON GROUNDNUT.
(*Plusia signata*, F.)
[*From S.S.I.*]

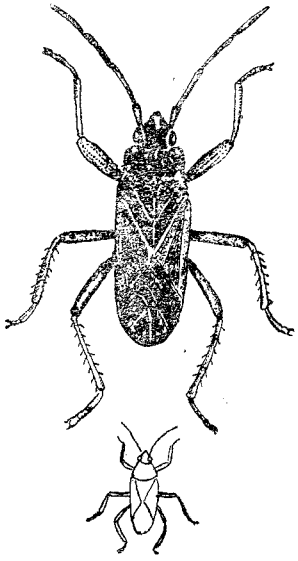


FIG. 165.—GROUNDNUT POD BUG.
(*Aphanus sordidus*, F.)
[*From S.S.I.*]

The groundnut Earwig (*Euborellia stali*, D.).—This is first example of an Earwig noted on field crop in South India. So far it has been noted in Coimbatore and South Arcot. It attacks the maturing underground pods and feeds on the kernels.

SAFFLOWER.*

THE SAFFLOWER CATERPILLAR—(*Perigoea capensis*, G., Fig. 166). —This is the only important pest of safflower so far noted in South India. It is a smooth green stout caterpillar with the anal segment

* *Carthmus tinctorius.*

humped and having some purple markings on the body; it often appears in numbers and defoliates the plants. It is found in Tirunelveli, Coimbatore, and in a few other places.

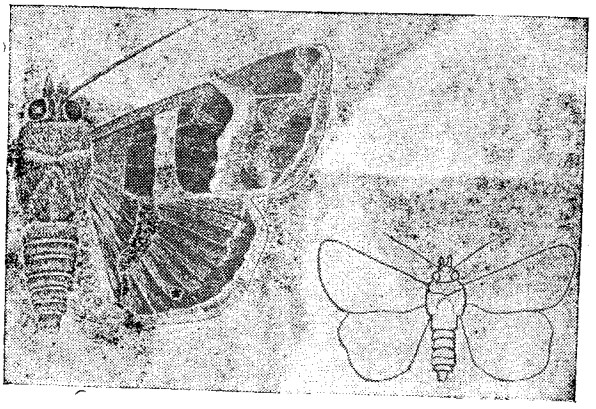
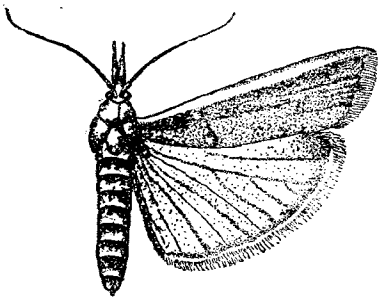


FIG. 167.—MOTH OF LINSEED CATERPILLAR. (*Grammodes stolida*, F.)

[*From S.S.I.*]



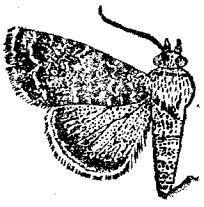


FIG. 166.—MOTH OF SAFFLOWER NOCTUID. (*Perigoea capensis*, G.)

[*From S.S.I.*]

Life history and habits.—The life history and habits are similar to some cut-worms like the gram, tobacco and ragi caterpillars. Pupation takes place in the soil. The adult is a dark brown medium sized moth with pale wavy marks on forewings. It is sometimes found subject to the attacks of fly and wasp parasites.

Control measures.—In bad infestations application of stomach insecticides will be found effective. Otherwise hand picking will check it in the early stages since the caterpillars feed gregariously.

The insects affecting the other oil-seed crops like mustard, niger, linseed, etc., which are not so extensively cultivated in South India are not very important. On linseed the dark red spotted caterpillar of a moth (*Grammodes stolida*, F., fig. 167) is occasionally noted as a minor pest feeding on the foliage. The pests of the coconut palm are dealt with under palms (page 312).

CHAPTER XIV.

Pests of Fibre Crops.

Cotton.

The insects associated with this important industrial crop number about two dozen or more, but the really serious pests do not exceed half a dozen in number. These include the following major pests—the spotted boll worm, the pink boll worm, the stem weevil, the stem jewel beetle, the leaf roller caterpillar and plant lice.

The Boll Worms.—These are the most serious of cotton pests in South India where there are two such categories which play the role of boll worms—one known as the spotted boll worm and the other as the pink boll worm.

The spotted boll worms—(*Earias fabia*, S., *and E., insulana*, *B.*, fig. 168).—These are the caterpillars of two moths of the genus *Earias* and are well-known all over India as shoot and boll borers of cotton. During the earlier stages in the growth of the cotton plant, they bore into the top shoots and when the plants put out bolls it bores into the ripening bolls and damage them. The damage caused in both ways is often very serious, though the injury done to the young plants is more conspicuous.

Life history and habits.—In South India, both the species of the spotted boll worms *Earias fabia*, *S.*, and *E. insulana*, *B.*, are generally found in all the cotton areas though the former species is the commoner form. The differences between these two are clearly noticeable only in the adult stage; in *E. fabia* the upper wing is pale white with a broad greenish band but in *E. insulana* on the other hand, the upper wing is completely green without any white inter space. In the other stages, these two insects are not easily distinguished. Sculptured shining bluish eggs are laid singly on the tender parts of the plant; if it is on a young plant the hatching larva bores down the top shoot, and if on a plant with bolls the caterpillar bites a hole through a tender boll and enters it. Inside the shoot or boll the worm grows feeding on the plant tissue. In young fields the presence of the pest is indicated by the drooping and fading top shoots which when opened reveal the presence of the caterpillar or its work. Attacked bolls show holes generally plugged with excreta; when full grown the caterpillar measures about two-thirds of an inch in length and at this stage it generally comes out of its burrow, and selecting a suitable spot on the plant

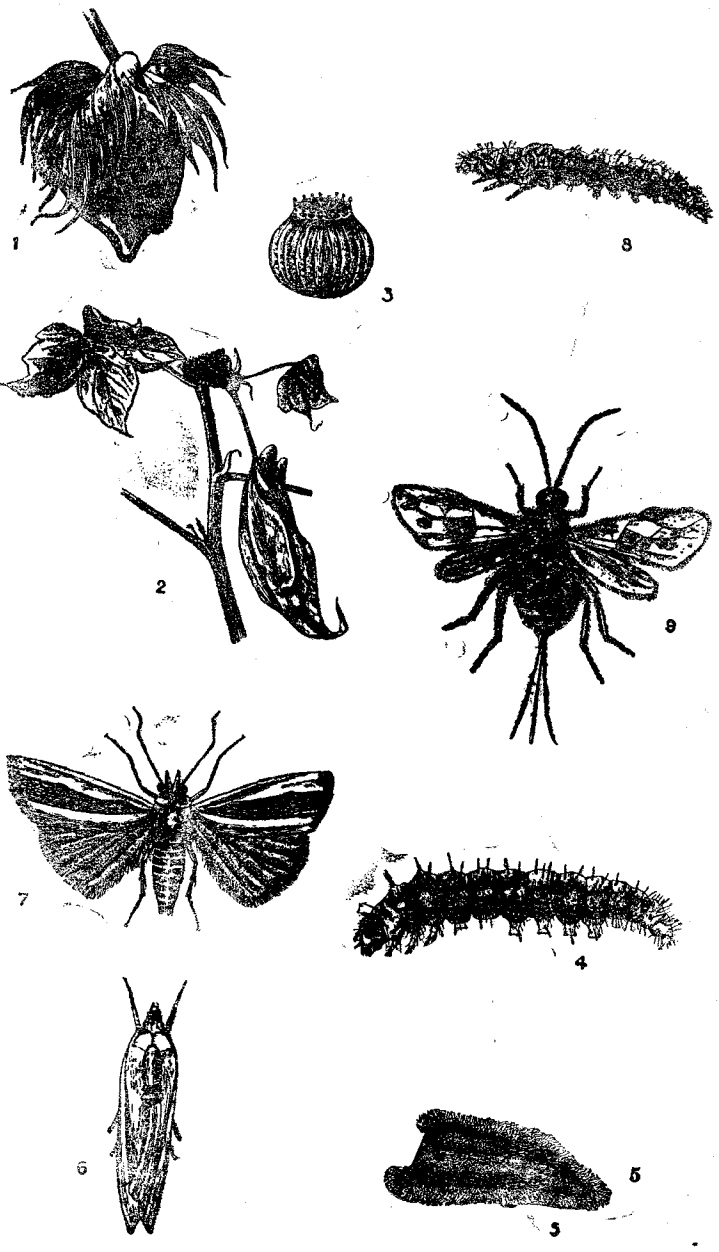


FIG. 168.—THE SPOTTED BOLL WORM OF COTTON.
(*Earias fabia* S.)

1 & 2 Attacked boll and shoot.
3 to 7 Egg, larva, pupa and moth (*E. fabia*).
8 Parasitised worm.
9 Parasite (*Microbracon*).

prepares a boat shaped cocoon of dirty brown silk and changes into the pupa inside the same. The cocoon is found on the surface of bolls, bracts and occasionally in cracks in the soil near the plant. One life cycle takes about 25 days (eggs 3—4, larva 10—12 and pupa 8—10 days). This boll worm is often attacked by parasitic wasps of two or three different kinds especially a small braconid (*Microbracon* fig. 168-9). Other plants on which this caterpillar feeds are the Lady's finger plant (*Hibiscus esculentus*), Shoe flower (*Hibiscus rosasinensis*), Abutilon, Hollyhock and some other malvaceous plants.

Control measures.—Being an internal feeder, only preventive methods will be feasible in this case. If the clipping and destruction of first attacked shoots are promptly attended to in the earlier stages of the crop, there will be considerable reduction in the pest population when the plants grow up and put out bolls. In cotton areas it is not advisable to grow *Hibiscus esculentus* when there is no cotton in the field. All malvaceous plants on which this insect breeds must be attended to. Parasites if found in numbers may be encouraged by use of parasite boxes in which the infested shoots and bolls may be kept to rear and distribute the parasites. These are small wooden boxes enclosed with wire gauze, the meshes of which do not allow the moths of the pest to emerge but only allow the small parasites to fly out.

THE PINK BOLL WORM—(*Platyedra gossypiella*, S., fig. 169).—This is an insect which has a very wide distribution all over the world, and is considered to be one of the worst pests of cotton. It is found in all the cotton areas of South India. As the name indicates this caterpillar is distinguished from the spotted boll worm by its uniform pale or deep pinkish color. It is a typical boll borer and causes appreciable damage. The caterpillar feeds inside the tender bolls and behaves in the same way as the spotted boll worm; but it does not attack the shoots like the latter.

Life history and habits.—Small flattish eggs are laid singly by the mother moth on the tender leaves, flowers and buds of the growing plant; these hatch in about a week into small pale whitish caterpillars which gradually find their way into the boll and feed on the contents. In about three weeks the caterpillar becomes full fed and at this stage it has a uniform pinkish color and is a little over half an inch in length. Pupation generally takes place inside the boll, often inside the portion of a seed hollowed out by the larva. The pupa is generally enclosed in a light silken cocoon and the adult emerges in about ten days. One life cycle occupies from three to six weeks according to weather conditions. The adult insect is a small blackish brown moth; it is nocturnal in habits and occasionally comes to lights. The insect practically confines its activities to cotton alone as it has not been found breeding on any other plant except in one recent instance when it was noted on

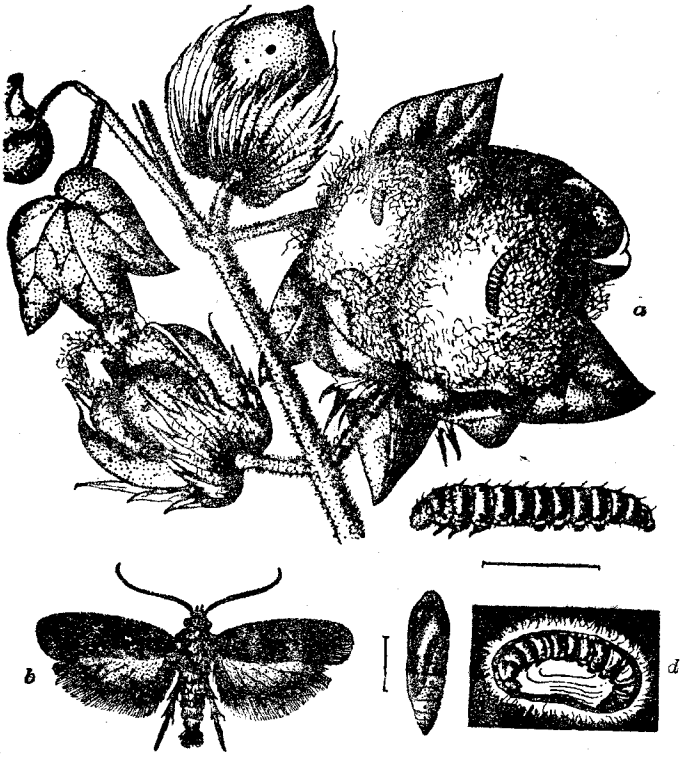


FIG. 169.—THE COTTON PINK BOLL WORM.
(*Platyedra gossypiella*, S.)
a Infested bolls. *b*, *c* & *d* Moth, caterpillar and pupa.

Hibiscus cannabinus on the Coimbatore farm. The insect does not also commonly remain æstivating in the larval or pupal stage for any long time in South India as it is found to do in other parts of the world. A few hymenopterous insects have now and then been noted to parasitise the caterpillar.

Control measures.—As in the spotted boll worm the remedies are mostly of a preventive nature. Good seeds should be used and it is safer to fumigate all seeds before sowing especially those got from outside. Early attacked and shed bolls should be promptly picked and destroyed to prevent the multiplication of the pest.

During the past decade or more a considerable amount of literature has accumulated on the boll worm pests of cotton as a result of research in different parts of India and outside on these and other important pests of cotton and these papers may be referred to for further information on these insects. There are quarantine rules in force against this pest in most of the cotton growing countries of the world and in this Province there is also the Pest Act which stipulates that all cotton plants (especially those

varieties particularly subject to the boll worms and stem weevil) should be removed from the fields by a certain fixed date in the year so as to give a close season of about two months before the next cotton crop.

In addition to these two important categories of boll worms, two other caterpillars have been occasionally noted in the Coimbatore area attacking the bolls. One is the notorious gram caterpillar (*Heliothis armigera*, H., fig. 170) known as the cotton boll worm in America; it has not, however, been noted as a regular pest yet. The other (*Rabila frontalis*, W.) is a stout caterpillar with a light pinkish color belonging to a yellowish brown moth. The habits are similar to the gram caterpillar. It has only been noted as a very minor pest till now.

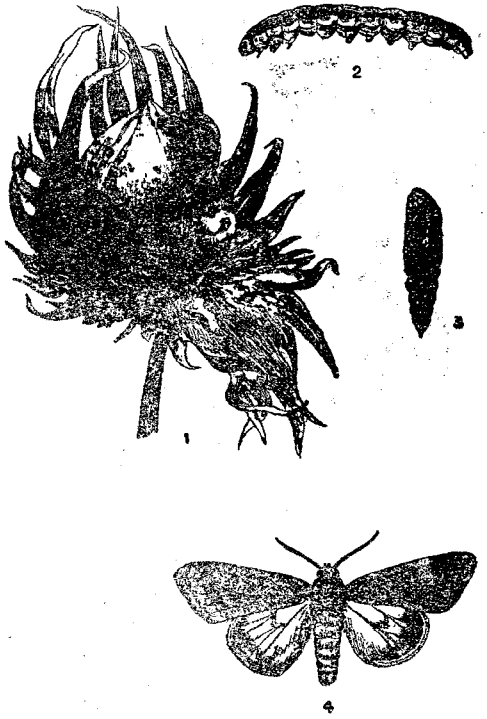


FIG. 170.—GRAM MOTH ON COTTON.
(*Heliothis armigera*, H.)
1 Attacked boll. 2, 3 & 4 caterpillar, pupa and moth.

THE COTTON STEM WEEVIL (*Fig.* 171)—(*Pempherulus affinis, F*).—Next to the two important boll worms, this insect ranks as a very important and serious pest of cotton in South India. It is a small dirty brown beetle about 1/8 of an inch in length with the curved snout very conspicuous. The insect has been noted in all the important cotton areas of South India and in Malabar also. As in the case of the boll worms it is the larva of the weevil that is injurious to

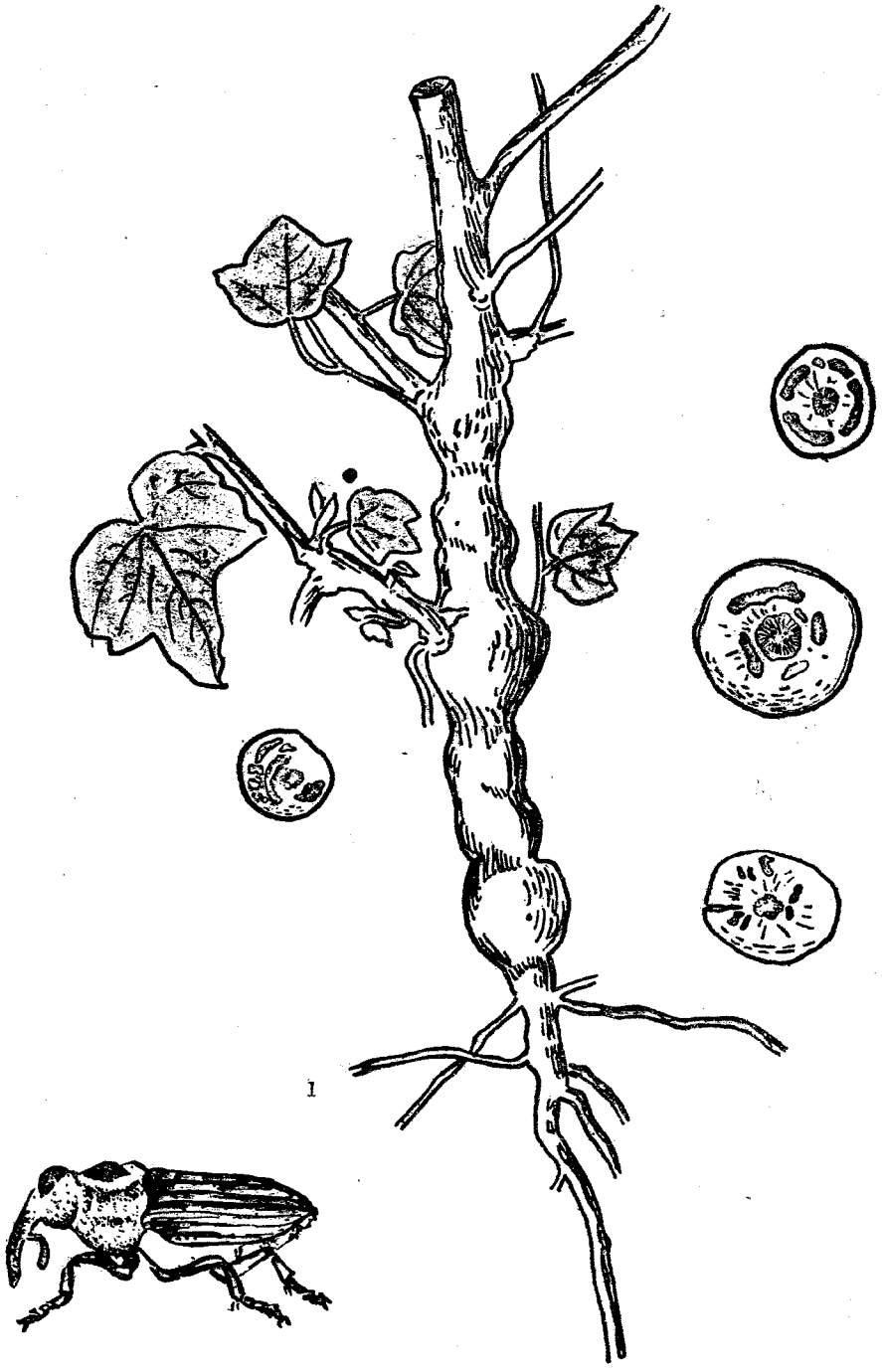


FIG. 171.— THE COTTON STEM WEEVIL.
(*Pempherulus affinis*, F.)
1 Infested cotton stem showing galls caused by the borer grub.
2 The adult weevil magnified.

[*From S. S. I.*]

the cotton plant. The injury to the plant consists in the young ones of the beetle burrowing into the stem, especially between the bark and the stem. Plants that are attacked in this way show the characteristic nodular swellings on the stem surface, generally at the lower portions of it just above the ground. When very young plants of a month or forty days are attacked the pest often kills the plant, but in the case of older plants many survive the attack, though they suffer in vigor. The external indication is generally visible on the plant only when the pest has almost completely done its work. During strong winds badly infested plants lodge and often break at or near the region of the stem where the nodular swellings are present.

Life history and habits.—The parent weevil deposits small shining whitish smooth eggs singly just under the surface of the bark of the growing plant. The small pale whitish yellow grub hatching out of the egg bites through into the region between the bark and the main stem and here makes irregular galleries, and this causes abnormal growth of the plant resulting in the formation of the swellings on the stem. Several grubs are often found in an infested stem. The pupa is also found inside the burrow. One generation in the life of the insect occupies roughly two months, the period of the different stages generally occupying nine to eleven days in egg, thirty to forty-five days as grub and ten to twelve days as pupa. Weevils have been kept alive in captivity for a month though it is not known how long they are able to continue alive in nature. Besides cotton the other plants on which the insect has been noted to breed to a certain extent are Gogu (*Hibiscus cannabinus*), Bhendai (*H. esculentus*), Sida, Abutilon and *Thespesia* seedlings. In Northern India it has been noted on *Triumfetta* sp. The pest can easily pass through several generations in the year if the host plants are kept on growing for months and years together as was the case with Cambodia cotton plants before the advent of the Pest Act. A few parasites have been noted on this pest and trials are being made to utilise them as Biological control.

Control measures.—Only such measures which are directed to prevent the beetle from multiplying and infesting fresh plants are found possible. Once a plant is badly attacked nothing can be done to save it from death or loss of vigor. But the systematic prevention by destroying first attacked plants will greatly reduce the numbers of the pest and thus minimize the damage. All cotton plants should be pulled out at the end of the cotton season so that there may not be any cotton on the ground for the pest to breed and pass on to the next cotton season. All cotton plants thus pulled out should be thoroughly dried in the sun so as to kill the grubs and pupae inside them which would otherwise remain there for some time and emerge later to infest fresh plants. It is not easy to catch the adult as it is very small in size and not commonly seen

in the fields, unless very carefuly searched for. The recent introduction of the Pest Act in some of the cotton areas of South India for the boll worms and this insect has concidarably reduced the the incidence of this pest in recent years.

THE COTTON LEAF ROLLER (*Fig.* 172)—(*Sylepta derogata*, F.),—This insect is a medium-sized moth having yellowish wings with brown wavy markings; the caterpillar of this creature rolls the leaves and feeds on the green matter. It is found all over South India. Infested plants can be very easily made out by the presence of numerous characteristic leaf rolls on the plants; when such a roll is opened, the caterpillar or the pupa can be found inside. In bad cases numerous rolls are visible on infested plants which are often defoliated.

Life history and habits.—The mother moth lays smooth flattish pale white eggs singly on the tender leaves usually on the under surface. The small greenish yellow caterpillar which emerges from each egg, within a week after hatching, begins to roll the leaves and live inside the rolls feeding on the leaf tissue. When full grown the larva is a little more than an inch in length and has a glistening green color with head and prothorax dark. The larva pupates in the roll itself and from the reddish brown pupa the adult moth emerges. The different periods of life cycle roughly occupy two to three days for the egg, fifteen to eighteen days for the larva and seven to eight days for the pupa and for one generation a month's time approximately. This insect feeds on different varieties of malvaceous plants especially on Bhendai (*H. esculentus*).

Control measures.—The control of this pest is not so difficult a matter as in the case of the some of those noted above. The leaf rolls in affected plants are easily recognized and the only thing to do is to collect these rolls and throw them into a bucket or tray containing some water and kerosene when caterpillars are at once killed. If these rolls are not observed early and the pest has increased, the plants can be sprayed with a stomach poison like Lead arsenate which will be found an effective remedy. However, the former method, if resorted to in time, is very easy and economic.

THE COTTON APHIS (*Fig.* 79)—(*Aphis gossypii*, G.).—Plant lice could be easily made out by the possession of a pair of honey tubes (cornicles) attached to the posterior end of the abdomen. This is very characteristic of these insects. They have the legs and the sucking proboscis well developed. The cotton aphis has a very wide distribution being found in all cotton areas and is also polyphagous in habits.

Life history and habits.—These minute insects infest the tender portions of the plant in colonies and suck up the plant sap. The drainage caused on the plant by thousands of these creatures produces a very unhealthy effect; the leaves become curled up, the tender portions fade gradually and the whole plant becomes more or

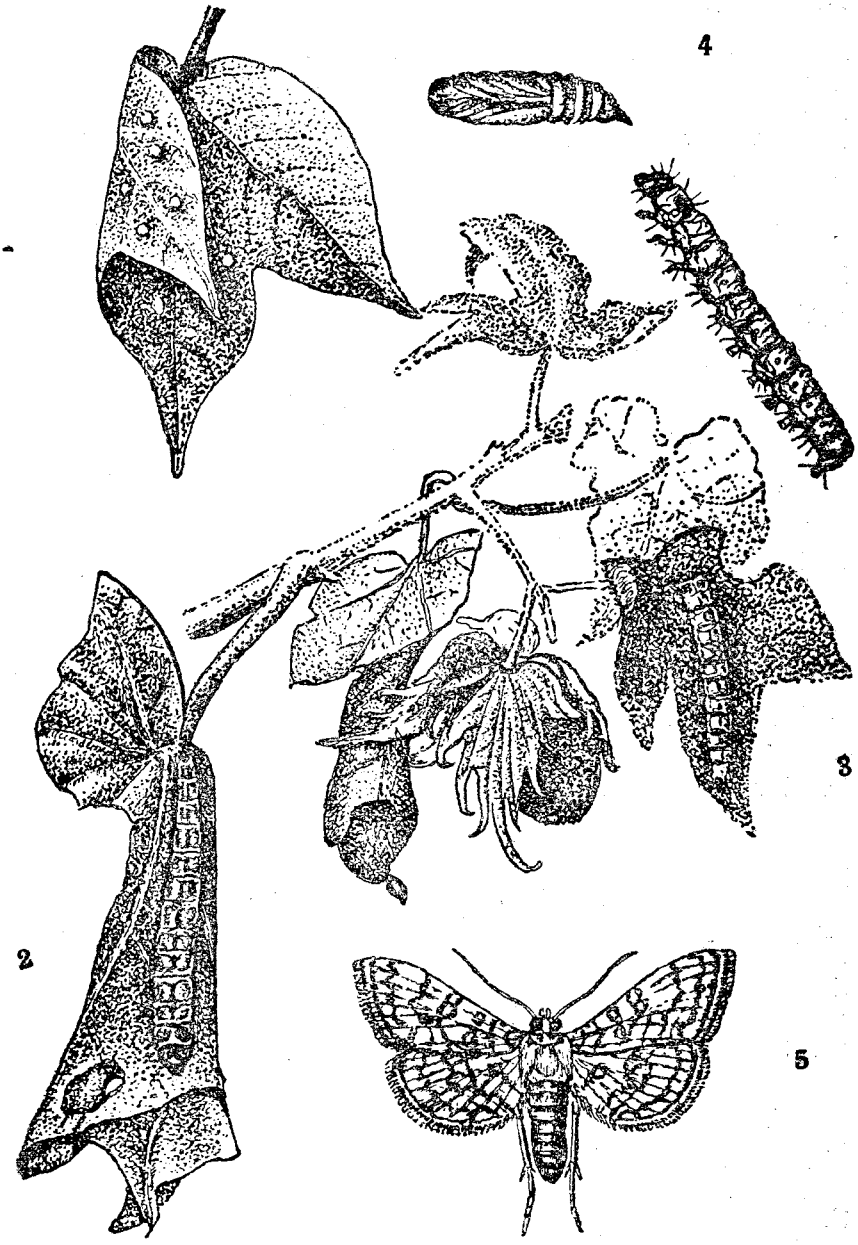


FIG. 172.—COTTON LEAF ROLLER
(*Sylepta derogata*)

1. Eggs on the cotton leaf.
2 & 3. Caterpillar on cotton leaf.
5. Moth.

less blighted in a bad attack. Plant lice multiply remarkably especially during cloudy weather. Very often they are able to multiply parthenogenetically, viz., the female insects giving rise to young ones without the previous connexion with the male, and commonly the creatures are viviparous also. When a plant is badly infestedand plenty of honey dew is thrown out by the plant lice, numerous bees, wasps and flies visit the plant for the liquid; in addition a black mould supervenes and the plants get a black blighted appearance, the leaves becoming sticky to the touch in this condition. In certain seasons, especially during cloudy weather, plant lice multiply remarkably and cause considerable damage to the crop. The lower surface of the leaves of badly infested plants is found covered with thousands of these small insects. It is also believedto be a transmitter of some plant diseases.

Control measures.—Plant lice, wherever they are found, are also accompanied by their natural enemies to a smaller or greater extent; the latter often do good work as a sort of natural check. The chief of these enemies are the following:—

Lady bird beetles—small spherical spotted beetles which, with their larvae, actively move on plants infested with plant lice and feed on them.

Hover fly larvae.

Lace-wing fly larvae.

All these insects, and especially their young ones feed voraciously on plant lice, and as far as possible the cultivator will do well to encourage these, at any rate not take them for pests and kill them. Figs. 22, 48 and 49.

In the early stages infested shoots may be pruned and burnt to prevent multiplication. In bad cases, where it is too late to do so, the application of a contact insecticide like fish oil soap, kerosene emulsion or tobacco decoction by means of a spraying machine or dusting with nicotine will kill plant lice effectively. The spraying should be thorough and applied twice or thrice at intervals of a fortnight or twenty days. The spray should reach the under surface of infested leaves where the colonies are mostly confined.

THE STEM BORING JEWEL BEETLE (*Fig.* 173)—(*Sphenoptera gossypii*, K.).—This is a shining coppery brown beetle of about a third of an inch in length belonging to the family of jewel beetles *Buprestidae* and allied to the groundnut *Verpuchi*. In this province this insect has been noted as a pest only in the Bellary tract and chiefly on American cottons, though it has a wider distribution in the different parts of Northern India. The damage done to cotton is by the whitish grub of this beetle which bores into the stem and in many cases kills the whole plant.

FIG. 173.—THE COTTON STEM BORING JEWEL BEETLE.
(*Sphenoptera gossypii*, K.)

1 Boring larva in plant stem. 2 and 3 Pupa and adult.

Life history and habits.—The parent beetle lays single eggs on the bark of the tender stem ; these hatch into grubs which burrow into the stem and tunnel through the same. The grub is of a pale whitish color, elongated and with a flattish anterior region. When full fed it pupates in the gallery and after the pupation period the beetle emerges through a hole previously prepared by the grub. The grub is often parasitized by wasps, especially by a Eulophid (*Euderus gossypii*, F.).

Control measures.—Destruction of first attacked plants and the collection of beetles when found in the fields.

MINOR PESTS OF COTTON.—The other insects found on cotton in South India are generally of minor importance, though now and

then some of them appear as sporadic local pests. These include the following :—

(1) *The Bud worm* (*Phycita infusella*, M., *Fig.* 174)—a small pale greenish caterpillar with dark head and prothorax.—It feeds inside a fold of leaves around the top shoots and buds. The insect appears when the plants are a month or two old, and infested plants show the peculiar fading of the top shoots. The pupa is also found in the leaf fold. The adult is a dark grey moth with a distinct whitish cross bar on each forewing. It is rarely found as a serious pest. The first attacked shoots can be removed; this will check the pest and help the plant in giving out fresh shoots.

FIG. 174.—COTTON BUD WORM.

(2) *Hairy caterpillars.*—These include the red tussock caterpillar (*Euproctis fraterna*, M., fig. 175), the red cholam caterpillar (*Amsacta albistriga*, W.) and the black castor hairy caterpillar (*Pericallia ricini*, F.). These are noted only occasionally on cotton. The life histories, habits and methods of control against them have already been noted under their important host plants.

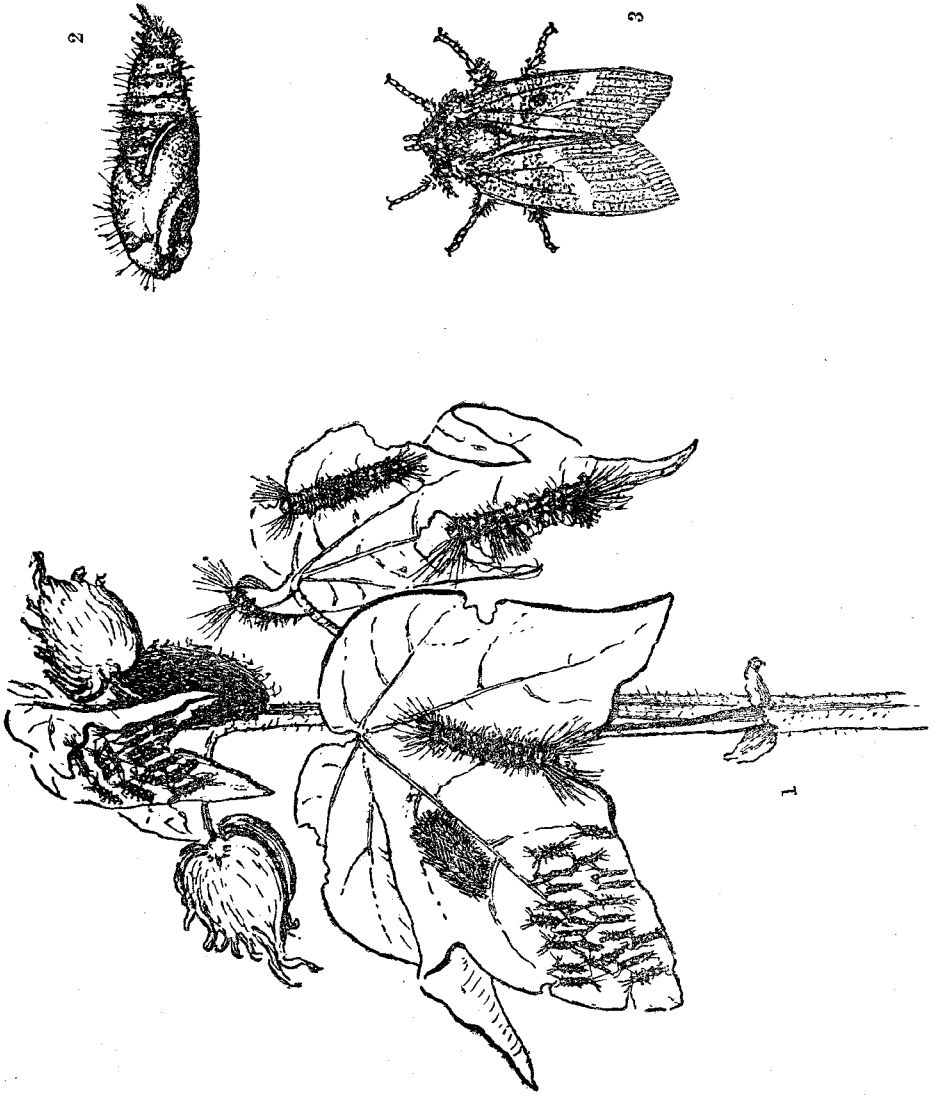


FIG. 175.—THE TUSSOCK MOTH ON COTTON.
(*Euproctis fraterna*, M.)
1 Caterpillars on plant. 2 and 3 Pupa and moth.

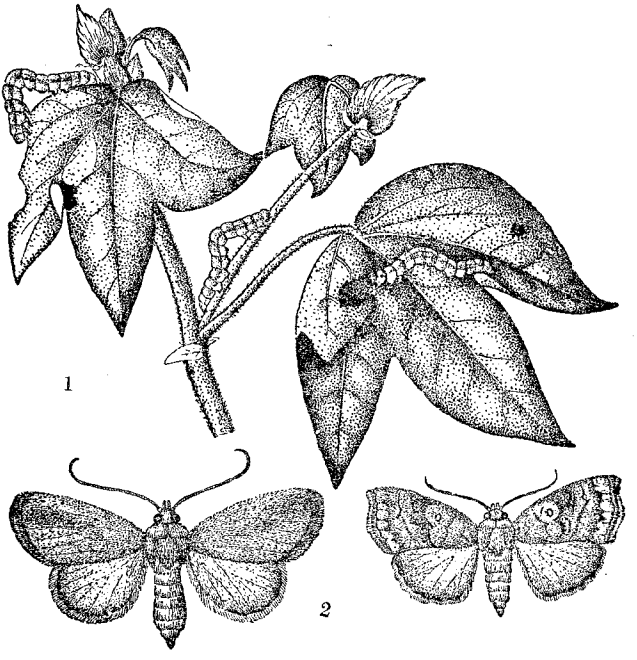


FIG. 176.—COTTON SEMILOOPER.
(*Anomis flava*, H.)
1 Caterpillars on plant. 2 Moth.

(3) *Semilooper caterpillars.*—These are also leaf-eating caterpillars occasionally found in different cotton areas. They include three familiar moths—*Anomis flava*, H., fig. 176, *Acontia graellsi*, F., fig. 198 and *Tarache nitidula*, F., (the Calotropis caterpillar), fig. 177; the larvae of all the three are typical loopers. The caterpillars of the two former are bright green in color with minute setae while that of the latter has a dark brown color. The adult of *Anomis* has brownish wings, *Acontia* has bright lemon yellow wings and *Tarache* bright cream white wings with dark markings. Another species *T. notabilis*, W., is also found on cotton occasionally. All these caterpillars can be easily handpicked and in bad cases, treated with a stomach insecticide.

(4) *Shoot weevil* (*Alcidodes affaber*, F., *Fig.* 178)—a dark greyish brown beetle with pale cross bands on the upper wings.—It is bigger than the cotton stem weevil (*Pempherulus*) and both the adult and the grub are found attacking the top shoots and leaf stalks. The life history is spent on the plant itself. It has not been noted as serious on cotton till now though on gogu it is occasionally bad as a stem borer. The other species noted in Northern India (*Alcidodes leopardus* Ol.), though found in South India on *Trichodesma* has not been noted on cotton and Fletcher's record appears to be incorrect. The pest can be easily controlled by handpicking the weevils and clipping the attacked top shoots.

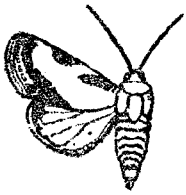


FIG. 177.—CALOTROPIS SEMI LOOPER MOTH
(*Tarache nitidula*, F.)

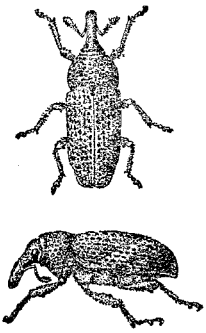


FIG. 178.—COTTON SHOOT WEEVIL.
(*Alcidodes affaber*, F.)

(5) *Grasshoppers* (*Cyrtacanthacris ranacea*, S., *and Catantops annexus*, B., *Figs.* 179 *and* 180).—These are occasionally noted as minor pests. The former is a stout big form usually known as the

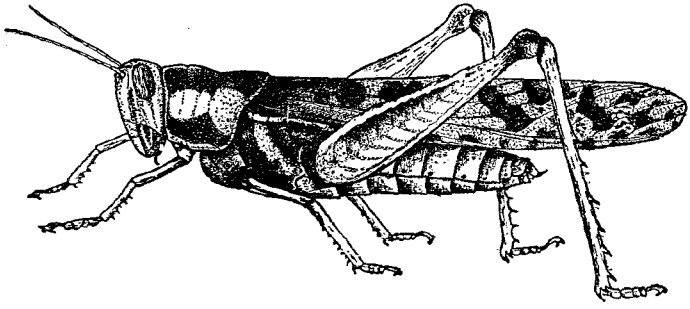


FIG. 179.—COTTON GRASSHOPPER.
(*Cyriacanthacris ranacea*, S.) [*From S.S. I*]

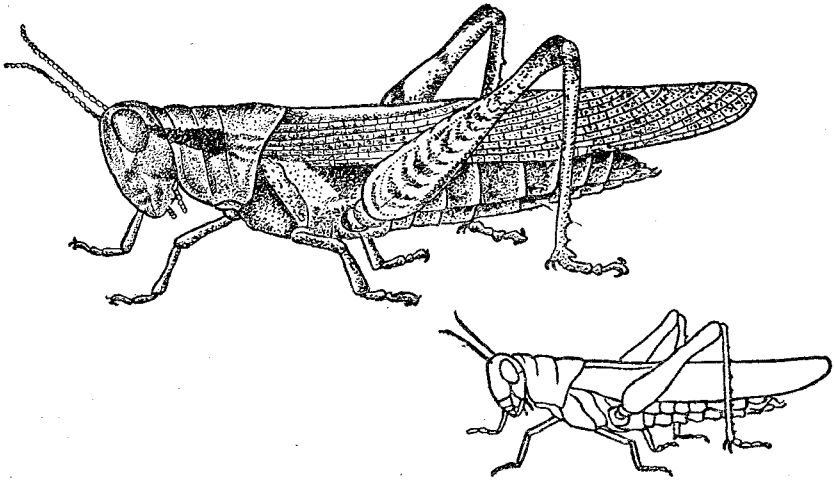


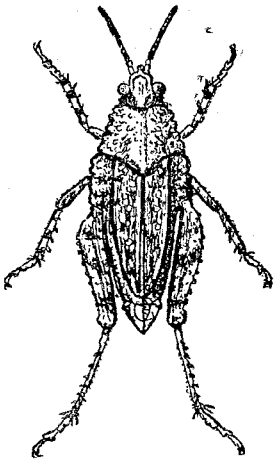
FIG. 180.—COTTON GRASSHOPPER OF TIRUNELVELI.
(*Catantops annexus*, B.) [*From S.S. I*]

cotton grasshopper or the Madras locust and has been found in all tracts of the province. The other is a smaller form which has been once or twice reported from the Southern districts as a sporadic local pest. Young cotton is often damaged by what are known as surface grasshoppers. They generally attack very young cotton and sometimes cause real damage to the seedlings. These include among others, two species—*Chrotogonus saussurei*, B., fig. 181 and *Aelopus tamulus*, F., fig. 110. When found in pest form these insects should be collected by handnets or bags and destroyed. In serious cases, spraying or trapping with stomach insecticides may be adopted.

(6) *Surface weevil* (*Atactogaster finitimus*, F., *Fig.* 182).—This is a fairly large dark grey weevil having the same habits as a surface grasshopper. It is a fairly common insect all over the province and in certain years it causes some damage to young cotton in the Tinnevelly area. The same treatment as for surface grasshoppers can be adopted ; the young plants can also be given a top dressing of some arsenate powder to check the pest as a preventive.

(7) *Flower beetles.*—The orange banded blister beetle (*Zonabris pustulata*, T., fig. 138) is a frequently found feeding on the flowers and pollen though not as a serious pest. A small smooth reddish brown weevil (*Amorphoidea arcuata*, M.) slightly bigger than the rice weevil (*Sitophilus oryzae*, L., fig. 333) has been noted on a few occasions breeding inside cotton flowers in Coimbatore and Saidapet. Though not a pest in South India, it is desirable to watch this insect, since a very closely allied insect (*Amorphoidea lata*, M.) is known to be a serious cotton pest in the Philippines.

(8) *Stink bugs.*—These are active bugs which breed chiefly on the cotton bolls puncturing the same, sucking up the juice and staining the lint. Two insects are chiefly concerned in this work, viz., the Red cotton bug (*Dysdercus cingulatus*, F., fig. 23) and the Dusky bug (*Oxycarenus loetus*, K., fig. 183). The former is the larger of the two and its general coloration is red with dark markings on the wings and pale white markings on the ventral side. Species of *Dysdercus* are known as 'Cotton stainers' in the West Indies. It lays masses of eggs on the soil near the plant and the young ones are often found feeding together on plants in numbers. It is also found on other malvaceous plants besides cotton. It is very rarely a serious pest of cotton. The dusky bug is smaller and has a uniform dusky brown color. The insect is found in all its stages in the infested bolls. Both these insects emit the characteristic buggy stink. The dusky bug appears generally in early opening or boll-worm damaged bolls. Both these bugs can be controlled by handpicking or netting, and in the case of the dusky bug by picking off the early attacked bolls and enclosing them in separate bags. The dusky bug has also been noted on gogu and allied malvaceous plants.



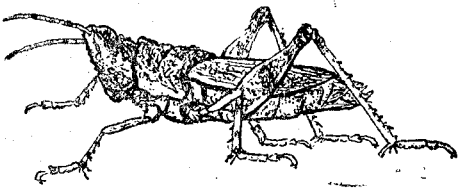


FIG. 181.—SURFACE GRASSHOPPER.
(*Chrotogonus saussurei*, B.)

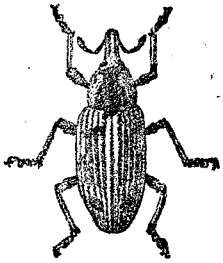


FIG. 182.—SURFACE WEEVIL.
(*Atactogaster finitimus*, F.)

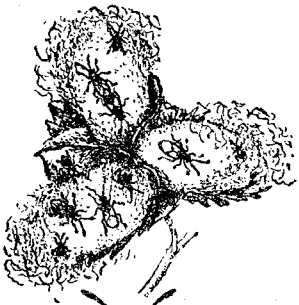
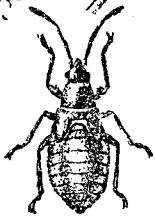
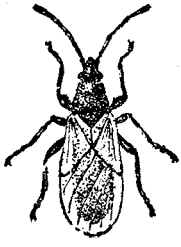


FIG. 184.—COTTON LEAF HOPPER.
(*Empoasca devastens*, D.)





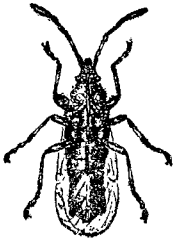


FIG. 183.—DUSKY COTTON BUG.
(*Oxycarenus lœtus*, K.)
Infested bills and stages of bug.

(9) *Leaf hopper bugs.*—The common insect of this group found on cotton is the hopper bug (*Empoasca devastens.* D. fig. 184). It is occasionally found to attack young cotton—especially some of the exotic varieties. It is a very small active green-winged insect which covers young plants in thousands and sucks up the plant sap. This mass attack causes leaf punctures, sap drainage and general weakness of the plants and in bad attacks leaf curling and withering also follow. It is of late getting into some prominence causing some appreciable damage to Cambodia cotton. In bad infestations it can be checked by nets, sticky winnows or by contract insecticides. DDT either in the form of dust or spray completely kills the pest. The calotropis hopper (fig. 323) is also found on cotton as a minor insect.

(10) *Scale insects and mealy bugs.*—Scales and mealy bugs sometimes play important roles as pests of cotton. Among scales there are three insects usually found—the small black scale (*Saissetia nigra*, N. fig. 308), the nim mealy scale (*Pulvinaria maxima*, G., fig. 324) and the yellow scale (*Cerococcus hibisci*, G., fig. 185). The small black scale is found on various plants like *Thespesia*, tea, coffee, etc.; the mealy scale is a specific pest of the nim tree especially in the Coimbatore tract and the yellow scale is a specific pest of cotton and allied malvaceæ found in all cotton areas. These insects are, as a rule, found to seriously damage only isolated plants in a field and not occur on a widespread scale. Scale covered plants suffer in vigour and become stunted. Two mealy bugs are occasionally noted on cotton plants—the tailed mealy bug (*Ferrisiana virgata*, C., fig. 218) and the massy mealy bug (*Pseudococcus corymbatus*, G.). Both these often completely cover some plants like the scales and cause the same injury as those insects. The control measures include prompt pruning and destruction of first infested plants and if necessary, an application of a contact insecticide.

Among other pests, which might, under favourable conditions, affect cotton badly may be added the white spotted flea beetle (*Monolepta signata*, O.) attacking young plants, thrips (*Thrips tabaci*, L.) noted in small numbers so far, leaf mites (chiefly *Anychus latus.*) and a bud gall fly (*Dasyneura gossypii*, F.) the larva of which bores into the cotton bud and causes some damage. This last insect which is a pest in the West Indies has been noted only in Coimbatore till now.

Gogu.

The important insect pests of gogu are the tussock caterpillar (*Porthesia scintillans*, W., fig. 186), the stem weevil (*Alcidodes affaber* F., fig. 178) and a specific flea beetle (*Podagria*). The caterpillar has already been referred to under castor. The weevil is an important pest of gogu especially in a crop grown for fibre since its grub often kills the main stem.

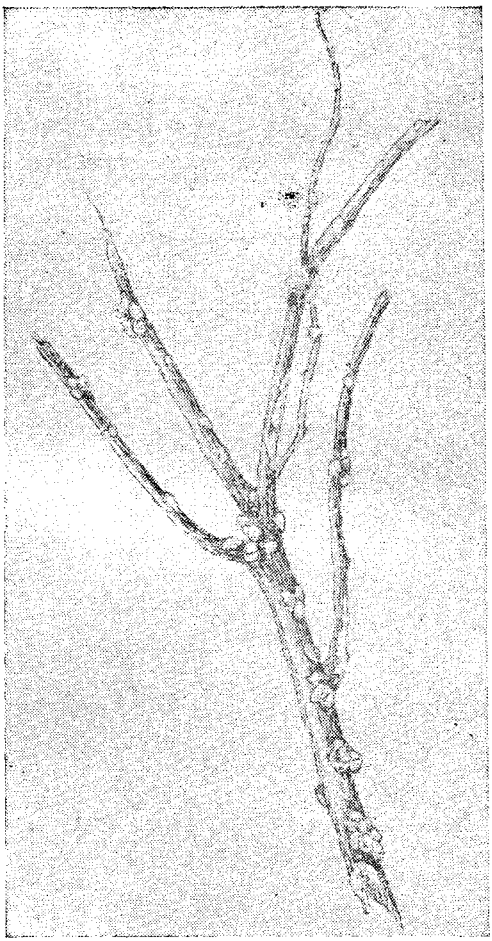


FIG. 185.—YELLOW SCALE ON COTTON.
(*Cerococcus hibisci*, G.)

[*From S.S.I.*]

The flea beetle (*Podagria madurensis*, J., fig. 187) is a small red and blue insect often found in numbers feeding on the foliage and making small holes. It is not a very important pest and can be collected with handnets and killed.

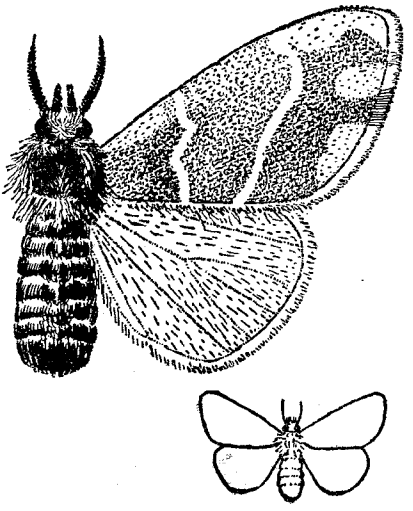


FIG. 186.—GOGU TUSSOCH MOTH.
(*Porthesia scintillans*, W.) [*From S.S.I.*]

Occasionally the blister beetle (*Zonabris pustulata*, T. fig. 138) is found feeding on the flowers and a stout grey weevil (*Dereodus mastos*, H.) as a leaf eater.

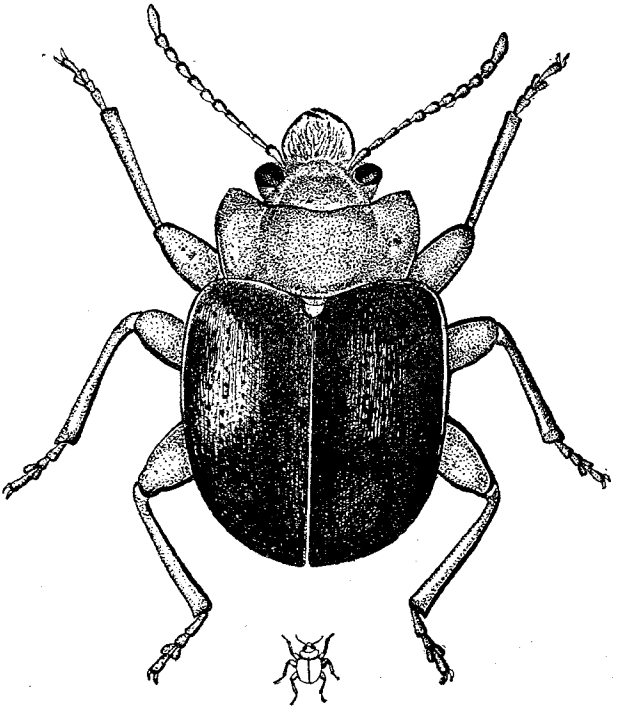


FIG. 187.—GOGU FLEA BEETLE.
(*Podagria madurensis*, J.) [*From S.S.I.*]

* Sannhemp.

The Sannhemp Hairy Caterpillar.—(*Utetheisa lotrix*, L.).—The most important pest of sannhemp all over the province is this hairy caterpillar. The caterpillar is not only a leaf feeder but bores into the seed capsules also. The adult moth is easily recognized by its pale whitish colour with red and black spots on the upper wings and black marginal blotches on the lower wings; it is popularly known as the 'Ermine-moth'. The insect is often a serious pest in different parts of the province (fig. 188) especially in the northern districts.

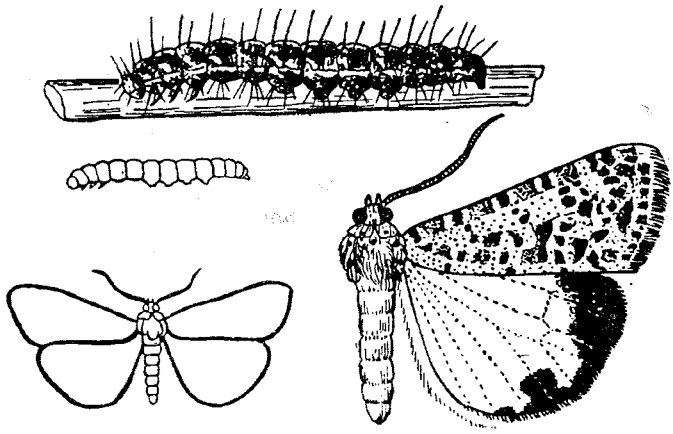


FIG. 188.—SANNHEMP HAIRY CATERPILLAR AND MOTH.
(*Utetheisa lotrix*, L.)

[*From S.S.I.*]

Life history and habits.—Small whitish eggs are laid on the tender leaves and shoots and during the younger stages of the plant the caterpillars feed on the leaves; on grown up plants the caterpillar thrusts its head end into the pod and feeds on the contents exposing the rest of its body. The caterpillar grows to 1½ inch in length and has the body spotted with red, dark and white markings with the head brownish. Pupation takes place either in the leaf folds or in the soil. In about five weeks one life cycle is passed. Besides sannhemp it occasionally breeds on some weeds like Heliotropium and wild Crotalaria, etc.

Control measures.—The moth which is easily recognized is a day flier and can be collected with nets and destroyed. In the early stages handpicking may be effective; but in bad infestations, application of stomach insecticides may be found beneficial. Light traps sometimes trap the moths in numbers.

* Crotalaria juncea.

Two other hairy caterpillars closely allied to this insect (*Argina cribraria, C., and A. syringa,* C.) are also noted often on sannhemp in company with the common form *U. lotrix,* L. The caterpillars of these two insects are very similar to that of the common species but the moths are different—one being a spotted orange and the other a spotted crimson moth. (Figs. 189 and 190). Their life histories are similar to *U. lotrix,* L. All the three moths are often found flying in the sannhemp fields during the day time.

THE SANNHEMP STEM BORER (*Enarmonia tricentra,* M.).—This is a small greyish brown moth the larva of which is found boring into the sannhemp stem and causing gall-like swellings on it. It is found in all areas in South India though it is rarely serious.

Life history and habits.—The caterpillar is about $\frac{1}{4}$ of an inch in length. It is smooth and has the head and thorax dark; the rest of the body is pale whitish but this gradually turns to pinkish as the larva grows. The larva burrows in the stem near the nodes and causes the swelling conspicuous on infested plants. It is really a bad pest when it attacks sannhemp grown for fibre. The pupa is also found inside this gall. The insect has not so far been noted on any other plant than different kinds of *Crotalaria.*

Control measures.—Preventive measures alone feasible; the attacked top-shoots can be clipped and destroyed to prevent further attack.

THE SANNHEMP CAPSID (*Fig.* 191)—(*Ragmus importunitas,* D.).—This is a small active green bug which causes some appreciable damage to sannhemp all over the province during certain years. The insect appears in swarms and sucks up the plant juice turning the plants pale and fading. The habits are exactly like those of the cholam earhead bug (*Calocoris*) and both belong to the same family.

Life history and habits.—The eggs which are white and cylindrical are thrust into the tender plant tissue generally under the surface layer. The young one in different stages feed on the plant in the same way as the parent, and all the stages are generally found on infested plants.

Control measures.—Mechanical methods of netting and use of sticky boards will be found effective, especially in a field where the crop is not very high.

The minor pests affecting sannhemp include (1) The flea beetle (*Longitarsus belgaumensis,* J.)—a very small active greenish brown insect biting small holes on the foliage, (2) a green semilooper leaf caterpillar (*Amyna octo,* G.) the adult of which is a brown moth, (3).

the pulse pod borer (*Etiella zinckenella*, T. fig. 145) sometimes attacks sannhemp pods also and (4) the blue butterfly (*Lamphydes boeticus*, L.) the short thickest greenish caterpillar of which is found boring into the pods (fig. 146). (5) A bruchid *Bruchus pisorum*, L. is also found on pods in Ceded districts and Circars.

AGAVE.

No serious pests have so far been noted on agave plants grown for fibre. They are occasionally bored by the palm rhinoceros beetle (*Oryctes rhinoceros*, L. fig. 264) and frequently attacked by snails (shelled animals—not insects) which produce the characteristic holes.

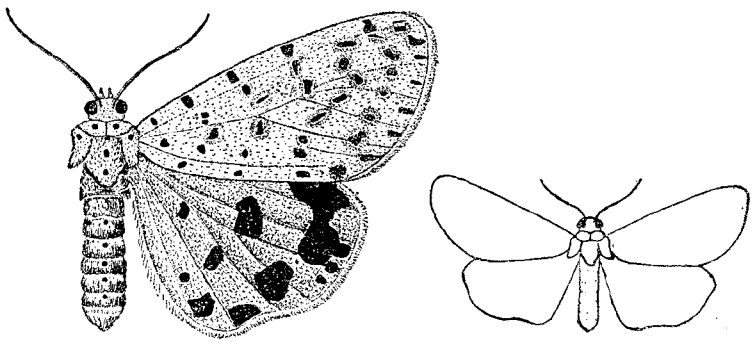


FIG. 189.—SANNHEMP MOTH (ORANGE COLOR).
(*Argina cribraria*, C.).
[*From S.S.I.*]

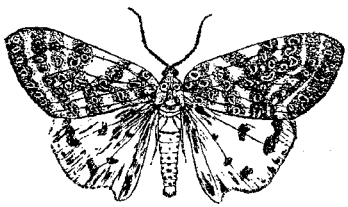


FIG. 190. SANNHEMP MOTH (CRIMSON COLOR).
(*Argina syringa* Cr.).
[*From S.S,I.*]

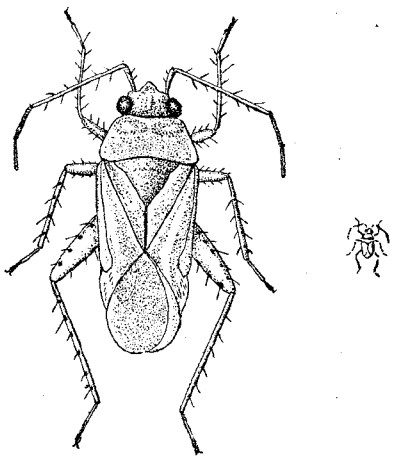


FIG. 191.—SANNHEMP CAPSID BUG.
(*Ragmus importunitas*, D.).
[*From S.S.I*]

CHAPTER XV.

Pests of Vegetables.

Almost all the vegetable plants of South India are subject to the damages by different kinds of insects. But unlike field crops, vegetable pests can be more easily checked and especially is this practicable in the suburbs of large cities where there is good demand for pest free vegetables which fetch good prices. The important vegetable crops from the province and the common pests they suffer from are noted below.

Brinjal.

This common vegetable plant is found attacked by about half a dozen insect pests. These are chiefly borers and leaf eaters, mostly caterpillars and beetles. A few sucking forms are also noted occasionally.

Borers.—(*a*) The shoot and fruit boring caterpillar (*Leucinodes orbonalis*, G., fig. 192-1)—The caterpillar is short and stout of a pinkish colour; it is found boring into the shoots of young plants and into the fruits, when the plants have grown up. Infested shoots show a faded drooping appearance and bored fruits show holes on the surface plugged with excreta. The insect is very common all over the province. The adult is a grey brown moth with whitish wings having pinkish brown markings on them. The life history and habits of the caterpillar are exactly like those of the spotted boll worm of cotton. The fullgrown caterpillar measures about of 2/3 of an inch in length and pupates in a boat-shaped cocoon of dirty brown silk on the plant itself.

(*b*) The stem-borer (*Euzophera perticella*, R.).—This caterpillar is also the larva of a moth; it is of a pale whitish colour and confines its activities to the plant stem. Pupation takes place in a silken cocoon inside the infested stem and the moth is a grey brown medium sized one bigger than that of the fruit borer caterpillar. Infested plants gradually fade and die. Though a serious pest, it is not so commonly found on young plants.

(*c*) The bud worm (*Phthorimœa blapsigona*, M.).—In this case the caterpillar bores into the tender buds and prevents fruit formation. Infested buds often drop down in numbers. Such buds show the small pale white or pinkish caterpillar and often also the pupa. The adult is a small brown moth very similar to the potato borer moth (fig. 203-4).

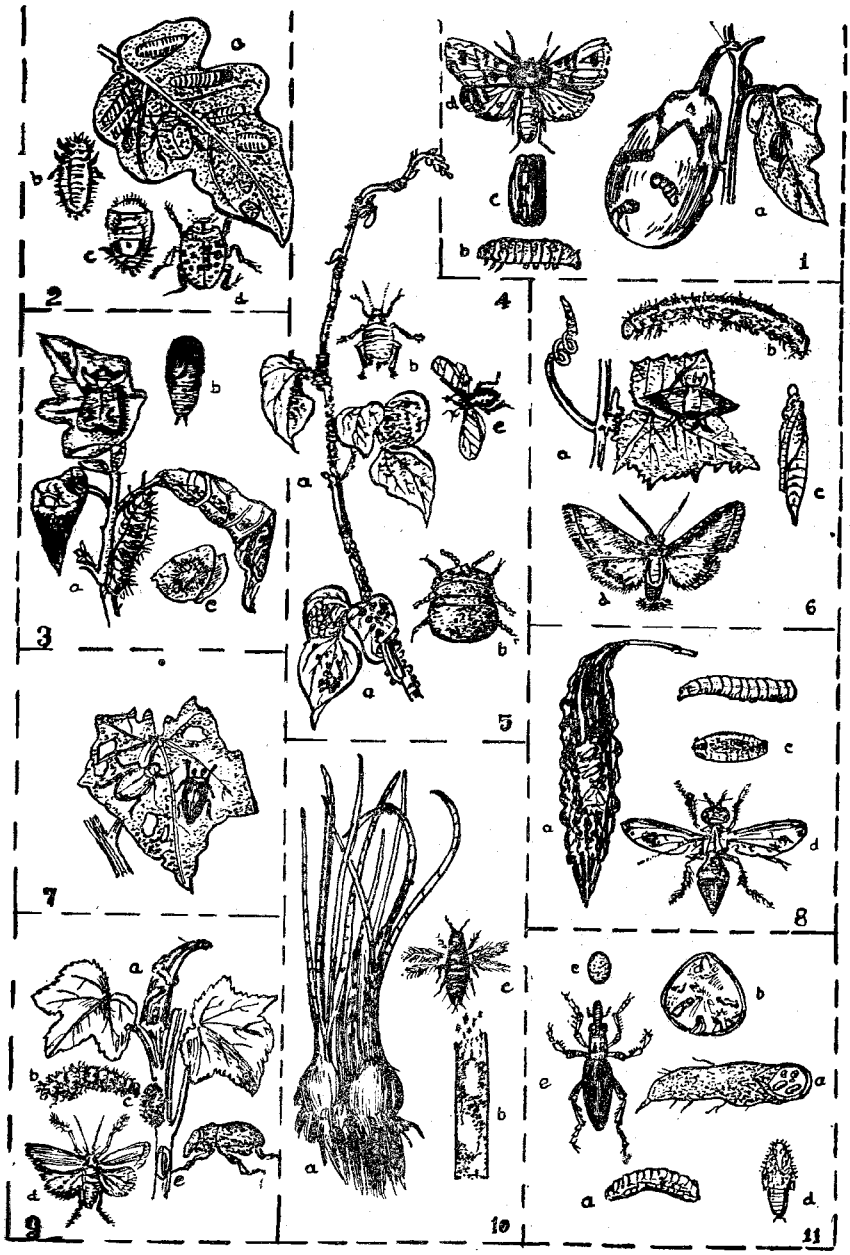


FIG. 192.—SOME VEGETABLE PESTS OF SOUTH INDIA.

1 Brinjal fruit borer (*Leucinodes*).
2 Epilachna beetle (*Epilachna*).
3 Brinjal leaf folder (*Eublemma*).
4 Lablab *Aphis*.
5 Lablab *Coptosoma*.
6 Pumpkin caterpillar (*Margaronia*).
7 Pumpkin beetles (*Aulacophora*).
8 Fruit fly (*Chætodacus*).
9 Hibiscus borer (*Earias*) and weevil.
10 Onion *Thrips*.
11 Sweet potato weevil (*Cylas*).

For all these borers only preventive measures can be adopted. Destruction of first attacked shoots, fruits and buds and helping the plants to grow vigorously by cultural methods will go a great way in checking these pests.

LEAF BEETLES.—*Epilachna beetles* (*E.* 12-*punctata*, M., and *E.* 28-*punctata* F., fig. 192–2.).—The most important of the leaf-feeding pests of brinjal are the Epilachna beetles. These spherical pale brown spotted beetles and their grubs scrape the green matter from the leaves and tender parts of the plant and often cause serious damage when they appear in numbers. All the stages, eggs in groups, the spiny fleshy grubs, the hemispherical pupæ and the active beetles are found on the plant itself. Handpicking of all the stages of the insect early in the season will effectively control the pest. In bad cases the attacked plants can be dusted or sprayed with Calcium, Magnesium, Lead arsenate or DDT. Sometimes other leaf-beetles like grey weevils (*Myllocerus* spp.) are noted on the foliage, and these can be treated in the same way as the Epilachna beetles.

LEAF CATERPILLARS.—Two or three leaf-eating caterpillars occasionally cause some damage to brinjal; the chief of these is the leaf-folder (*Eublemma olivacea*, W., fig. 192-3) which rolls up the leaves and feeds on the green

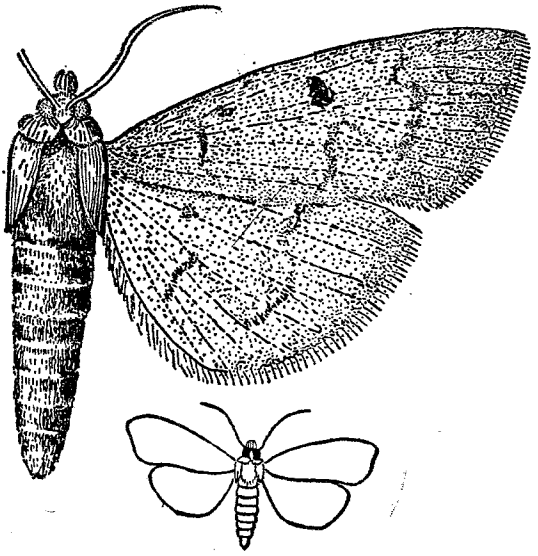


FIG. 193.—BRINJAL LEAF WEBBER—MOTH.
(*Psara bipunctalis*, F.)

[*From S.E.I.*]

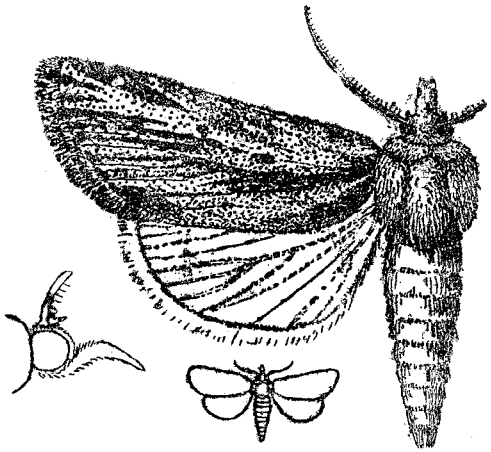


FIG. 194.—BRINJAL HAIRY CATERPILLAR MOTH.
(*Selepa docilis B*).

[*From S.S.I.*]

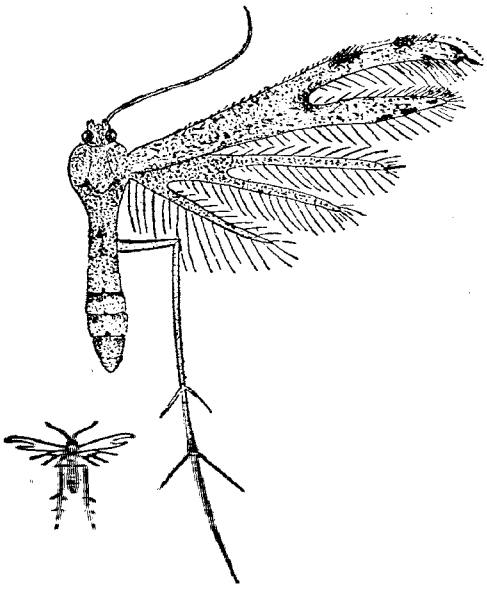


FIG. 195.—BRINJAL PLUME MOTH.
(*Oidaematophorus lienigianus*, Z.)
[*From S S I*]

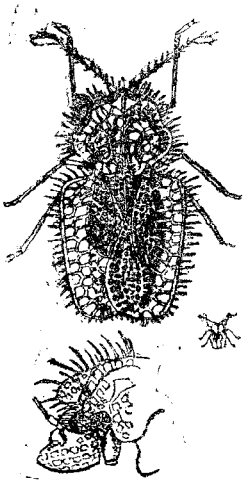


FIG. 196.—BRINJAL LACE WING BUG.
(*Urentius echinus*, D.)
[*From S.S.I.*]

matter remaining inside the fold. It is a stout purple brown caterpillar with yellow spots and hairs and is the caterpillar of an olive green winged moth. The other caterpillars now and then found are the leaf-webber (*Psara bipunctalis*, F., fig. 193) and the sphinx caterpillar (*Acherontia styx*, W.) noted under gingelly, fig. 91–3. The former is a gregarious caterpillar often found in numbers, webbing a single leaf and remaining inside the fold. A small greenish caterpillar (*Phycita clientella*, Z.) is occasionally found as a leaf-roller, and in some places a small hairy caterpillar (*Selepa docilis* B. fig. 194) attacks the leaves. A plume moth caterpillar (*Oidaematophorus lienigianus*, Z., fig. 195) is also found at times but never as a serious pest. In bad attacks of these leaf caterpillars stomach insecticides may be employed.

SUCKING INSECTS.—These include plant lice, mealy bugs, scales and lace-wings. A lace wing bug (*Urentius echinus*, D., fig. 196) is sometimes serious. The habits of these lace-wing bugs have already been noted on page 72. This species has a dark brown colour and is fringed with small spines. The damage done often turns the leaves yellow and makes them dry and drop off. The brinjal mealy bug (*Phenacoccus insolitus*, G., fig. 197) generally attacks isolated old plants and the infested ones are so covered by these mealy covered insects that the plants appear as though covered with white-wash. For these sucking insects tobacco may be employed either in the dry condition or as a decoction. The big dark-bug (*Anoplocnemis phasiana*, F., fig. 147) noted under cow-pea is occasionally found on brinjal also. Small ants are also now and then found nibbling the tender shoots, leaves and buds of brinjal plants.

MARTHANGALI.*

This is a common plant the fruits of which are used as vegetable all over South India. It is subject to the attacks of plant lice (chiefly *Aphis rumicis*, L.) and *Epilachna* beetles.

LADY'S FINGER †—*Bhindi.*

The important insects affecting this plant are some of the well known cotton and gogu pests—the spotted boll worm (*Earias* sp.) the leaf roller (*Sylepta*), the semilooper caterpillars (*Anomis* & *Acontia*, fig. 198) and the gogu stem weevil (*Alcidodes affaber*, F.). Occasionally small green leaf weevils (*Myllocerus* spp.), a red and blue flea beetle (*Podagria bowringi*, B.), green leaf hopper bugs (*Jassids*) and black scale (*Saissetia nigra*, N., fig. 308) and mites, appear in small numbers. The jassids and mites occasionally become serious and the former can be controlled by DDT and the latter by Sulphur. Bhendi sometimes suffers from root eel worms also especially along the West Coast.

* Solamum nigrum. † Hibiscus esculentus.

Cluster Bean.*

This plant is not seriously injured by any insect pest. Leaf weevils (species of *Alcidodes, Blosyrus*, etc.) occasionally breed and feed on the top shoots, and the lablab bug (*Coptosoma*) often clusters on the tender shoots and sucks up the sap. The gingelly gall fly (fig. 157) is found attacking the flowers of this plant.

Sweet Potato.

The Sweet potato weevil (*Fig.* 192-11)—(*Cylas formicarius*, F.).—This ant-like red and blue weevil is the most important of sweet potato pests and has a very wide distribution all over the tropics. The grub of this beetle bores into the vines and often serious damage is caused to the crop. In addition it is also a pest in the vegetable godowns since it bores into the stored potato tubers also.

Life history and habits.—The parent beetle bites small holes on the stem and tubers and lays the oval whitish eggs inside them. The footless pale yellowish white grub bores into the tissue and grows by feeding on the inner contents. Inside badly infested vines and tubers can be seen the different stages of the weevil in numbers. The former gradually begin to fade and dry while an infested tuber shows dirty patches on the surface with stray holes here and there, being the exit holes of already emerged weevils. It has not been found to breed on any other plant so far, nor has any effective natural enemy been discovered in South India.

Control measures.—Selection of pest-free vines for planting, prompt disposal of weevil infested tubers in the vicinity, collection and destruction of weevils when noted in the fields and prompt destruction of first attacked vines will help in checking the multiplication of the pest. Deep rooting varieties of the plant will also prevent infestation as compared with surface rooters which are easily liable to weevil attack being nearer the surface or even exposed. In vegetable godown all infested tubers should be destroyed and if possible the rest fumigated. Another vine borer which is a moth caterpillar (*Omphisa anastomosalis, D.*) is found attacking the vines similar to the weevil but is not very common; it is found on wild Ipomœaceous plants also—fig. 199.

Leaf Beetles.—These include the metallic colored tortoise beetles (such as *Aspidomorpha miliaris*, F., fig. 200 *Metriona circumdata*, H., fig. 201. and *Chiridia sexnotata*, B.) and a small spiny hispid beetle (*Oncocephala tuberculata*, O.) See fig. 33 of the curious grub of the first. A small leaf miner buprestid beetle (*Trachys ipomeae*, Th.) has also been noted as a minor pest of sweet potato recently in parts of Coimbatore.

* Cyamopsis.

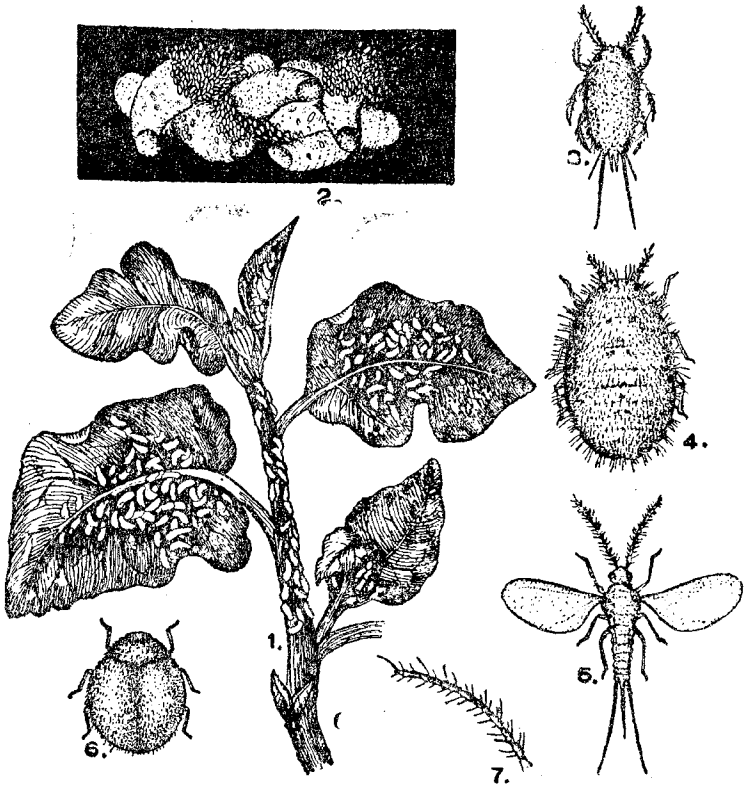


FIG. 197.—BRINJAL MEALY BUG.
(*Phenacoccus insolitus*, G.)

1 Bug infested plant.
2 Egg sacs.
3 Larva.
4 Young female.
5 Winged.
6 Predatory lady bird beetle (*Scymnu castaneus*, S.)
7 Antenna of male bug.

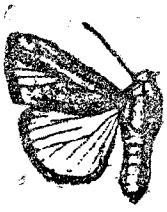


FIG. 198.- MOTH OF SEMILOOPER ON BHINDI.
(*Acontia groellsi*, F.)

[*From S.S.I.*

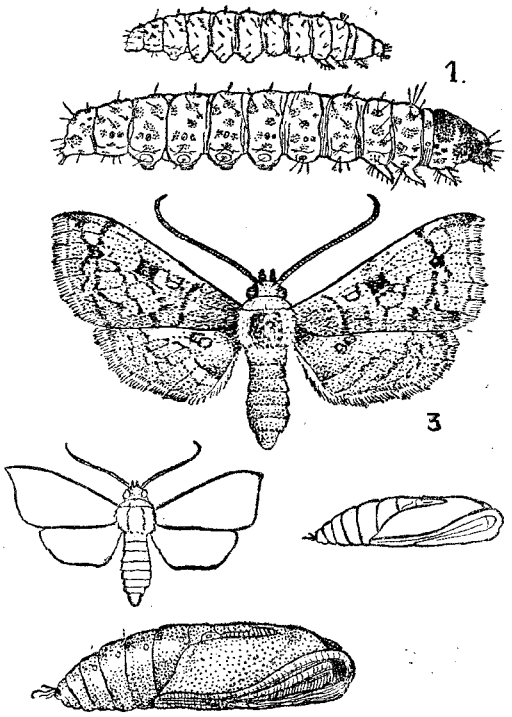
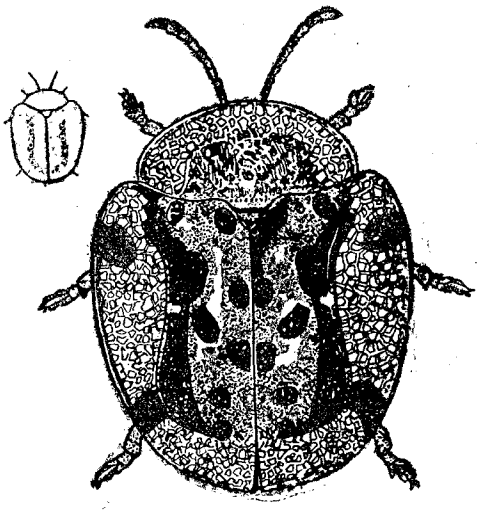


FIG. 199.—IPOMOEA VINE BORER.
(*Omphisa anastomosalis*, G.)
1 Larva. 2 Pupa. 3 Moth
[*From S.S.I.*]

LEAF CATERPILLARS.

The well-known leaf caterpillar of sweet potato pratically all over the world is the sweet potato sphinx (*Herse convolvuli*, L., figs. 202 and 91–1) the same insect noted under gram on page 192. Other minor caterpillars include a stout reddish brown cylindrical spotted caterpillar (*Catephia inquieta*, W.), a very small slender leaf-folder (*Lecithocera effera*, M.), a spiny butterfly caterpillar (*Precis orithyia*, L.), a syntomid (*Euchromia polymena*, L.) and a hairy caterpillar (*Diacrisia obliqua*, W., fig. 90-6). This hairy caterpillar is generally found in Northern India as a miscellaneous pest of various crops and is known as the Behar hairy caterpillar; in South India it has been chiefly found on the hills and submontane areas of the West Coast attacking different crops, especially pulses,



FEG. 200.—SWEET POTATO BIG TORTOISE BEETLE.
(*Aspidomorpha miliaris*, F.)

[*From S.S.I.*

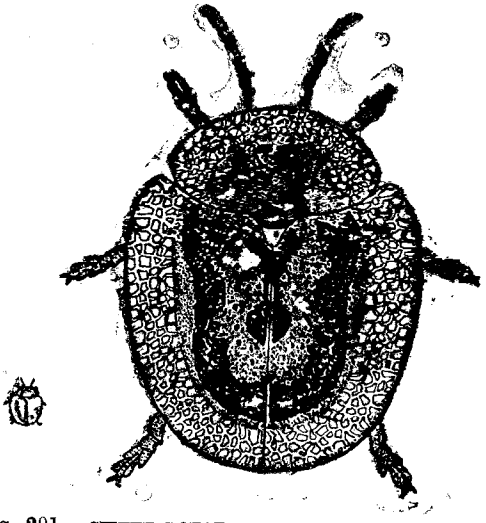


FIG. 201.—SWEET POTATO SMALL TORTOISE BEETLE.
(*Metriona circumdata*, H.)

[*From S.S.I.*]

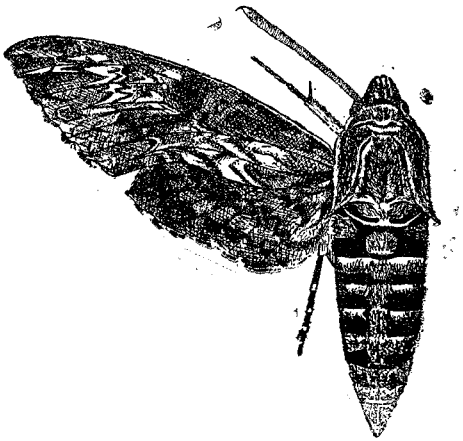


FIG. 202.—SWEET POTATO SPHINX MOTH.
(*Herse convolvuli*, L.)

[*From S.S I*]

POTATO.

THE POTATO TUBER MOTH.—(*Fig.* 203-4)—*Gnorimochema operculella*, Z.).—This well-known pest of potato has a worldwide distribution and like the sweet potato weevil is found both in the field and in godown. In South India it is more a store pest attacking stored potatoes in the vegetable godowns. Sometimes it causes serious damage. Badly infested tubers when cut open disclose tunnels and galleries made by the borer caterpillar often with the latter *in situ*. The moth is also seen flying about in the godowns. In South India this insect is chiefly found on the hills (The Nilgiris, Shevaroys, etc.), and in the Mysore plateau where alone potato is generally grown.

Life history and habits.—Eggs are laid generally on the eyes of the potatoes and the caterpillars tunnel into the tuber and grow into pale whitish brown worms reaching a length of about half an inch. The caterpillar pupates in a coarse silken cocoon on the potato or even on the gunny bag in which the tubers are stored.

Control measures.—Insect infested potatoes should be disposed of to get rid of the pest in them. Only clean tubers should be stored and these in containers which are also free from pupae and caterpillars of the pest lurking in the corners and cracks. Sand storing of potatoes is sometimes found to keep off this pest. In parts of Northern India where potato is extensively cultivated some methods are in vogue to control this pest viz., storing of potatoes in bins washed with D.D.T., chalk, etc., trapping of the moths with oils of sorts, etc., and these have been found successful to some extent in parts of Bihar. The transport of infested potatoes distributes the pest from place to place, this should be avoided.

Some Caterpillar Pests of Vegetables.

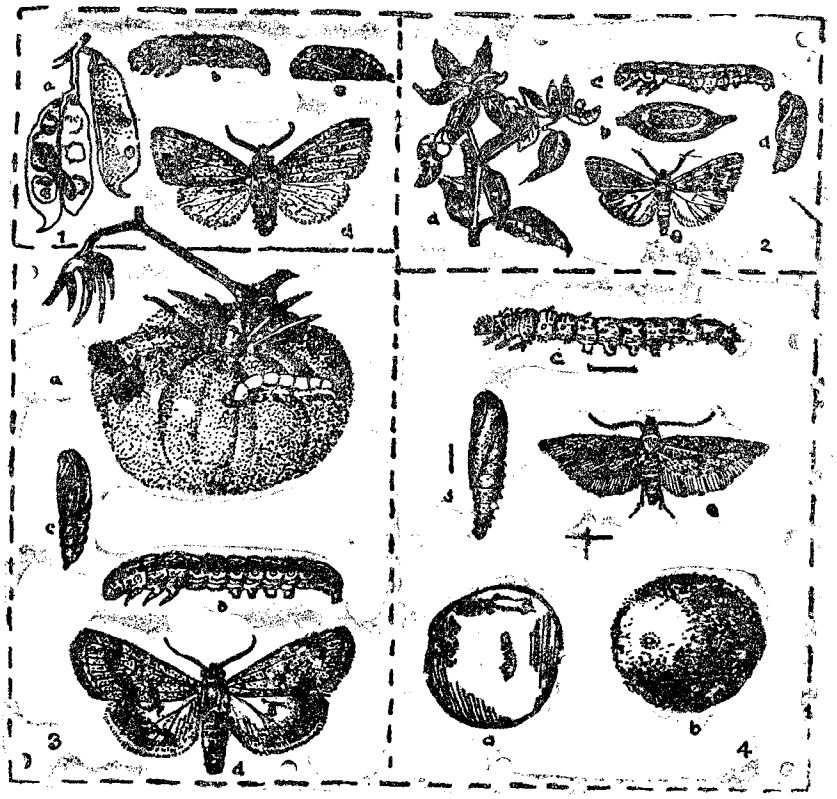


FIG. 203.—SOME CATERPILLAR PESTS OF VEGETABLES.

1 Lablab pod-borer (*Adisura atkinsoni*, M.)
2 Chillies caterpillar (*Laphygma exigua*, H.)
3 Tomato borer (*Heliothis armigera*, F.)
4 Potato borer (*Gnorimochema operculella*, Z).

The other pests of potato are not of much importance. Epilachna beetle (*Epilachna*, fig. 192-2) is occasionally bad in the Mysore area. On the hills the growing plant is occasionally damaged by one or two species of dark brown smooth cutworm caterpillars (chiefly *Euxoa segetum*, S., fig. 83-4) which cause serious harm to the crop. In bad infestations these have to be trapped by baits or killed by using stomach insecticides. Recently the use of B.H.C. 5% has been so effective against this pest that it has become almost a regular practice on the Nilgiris. Wire worms ants

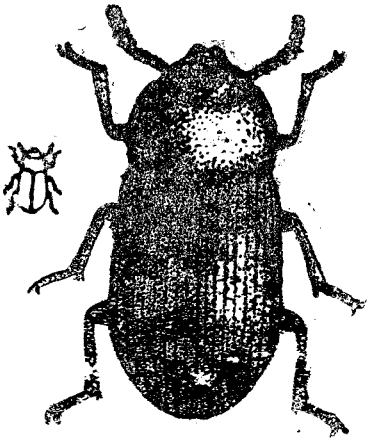


FIG. 204.—GROUND BEETLE ON PLANT ROOTS.
(*Gonocephalum hofmannseggi*, S.)

(*Dorylus* sp.) and ground beetles (*Drasterius* sp., fig. 86, and *Gonocephalum hofmannseggi*, fig. 204) are occasionally found as underground pests nibbling at the tubers. The green plant bug (*Nezara viridula*, L., fig. 125) noted under cumbu is also sometimes found on this plant. A green leaf beetle (*Chalaenosoma metallicum*, F.) has been noted on potato plants on the hills as a leaf eater but not as a pest. On the Nilgiris the author has noted sprouts of seed potatoes often subject to the attacks of an aphid (*Myzus persicae* S.) even while in the seed godowns.

DRUM STICK.*

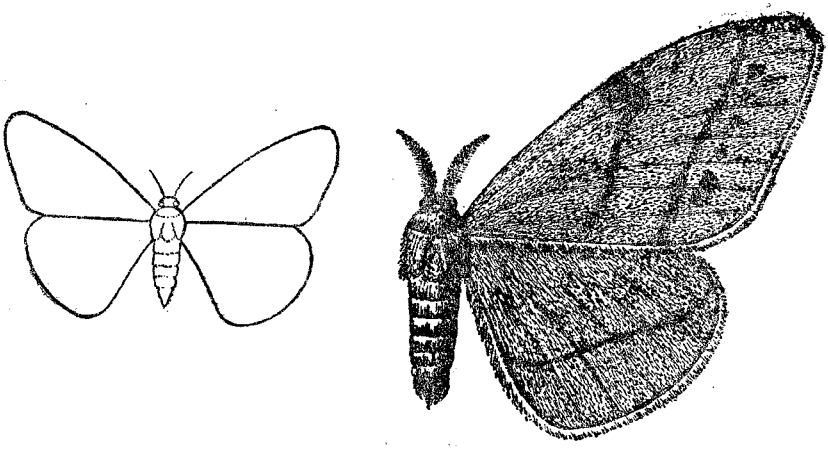


FIG. 205.—MOTH OR MORINGA HAIRY CATERPILLAR.
(*Eupterote mollifera*, W.)

[*From S.S.I.*]

THE HAIRY CATERPILLAR.—(*Eupterote mollifera*, W., *Figs.* 205 *and* 90–10).—This insect is a specific pest of this vegetable plant in South India—a fairly long dirty brown hairy caterpillar which

* *Moringa pterygosperma.*

is often found covering the shoots and stems of the plant in thousands. These feed on the foliage and scrape the bark also.

Life history and habits.—Eggs are laid in groups on the tender shoots and leaves, and from these hatch out small brown hairy caterpillars ; these gradually grow to about an inch and three-fourths in length. The body is elongated and dirty grey brown covered with small warts giving rise to numerous tufts of poisonous and irritating hairs. The adult insect is a large-sized moth having a uniform light yellowish brown color (fig. 205).

Control measures.—The caterpillars found together in numbers on tree trunks can be burnt with a lighted torch. Spraying with Fish oil Rosin Soap or dusting with BHC 5% on the gregarious mass of caterpillars exterminates the pest. Occasionally the black castor hairy caterpillar (*Pericallia ricini*, F., fig. 159-7) is also found on the moringa tree.

FIG. 206.—MOTH OF MORINGA LEAF CATERPILLAR.
(*Noorda blitealis*, *W.*)
[*From S.S.I.*]

A small greenish caterpillar (*Noorda blitealis*, W.) the larva of a blackish moth is occasionally found feeding on the tender foliage and flowers—fig. 206 ; a closely allied species *N. moringæ*, M.B. has also been noted in Coimbatore. In Travancore another caterpillar of the same family (*Protrigonia zizanealis* S.,) has been noted on this tree.

A stem-boring longicorn beetle (*Coptops aedificatar*, F.) has been noted on moringa stem on a few occasions on the Coimbatore farm ; the whitish grub bores into the stem and kills the latter. A gall fly (*Stictodiplosis moringae*, M.) attacking the buds is also a minor pest.

CUCURBITS (*Pumpkins, cucumbers, gourds, etc.*)

The insects affecting the various species of cucurbitaceous plants like pumpkins, melons, gourds, etc., are all similar except in very few cases where a few are especially partial to some of them. The chief pests include the epilachna beetles (*Epilachna* spp.) already referred to under brinjal and potato, some leaf caterpillars, pumpkin beetles, fruit flies, plant bugs and plant lice.

LEAF CATERPILLARS.—The pumpkin caterpillar [*Margaronia indica*, S. Figs. 192 (6) and 207]. This is an elongated bright green caterpillar with a pair of narrow longitudinal white streaks

along the mid-dorsal line. It feeds on the foliage and pupates inside a leaf-fold in a flimsy silken cocoon. The moth is also a conspicuous creature having transparent whitish wings with dark broad marginal patches. The gravid female moth has a tuft of orange colored hairs at the anal end. This insect is found on all cucurbitaceous plants and can be easily made out.

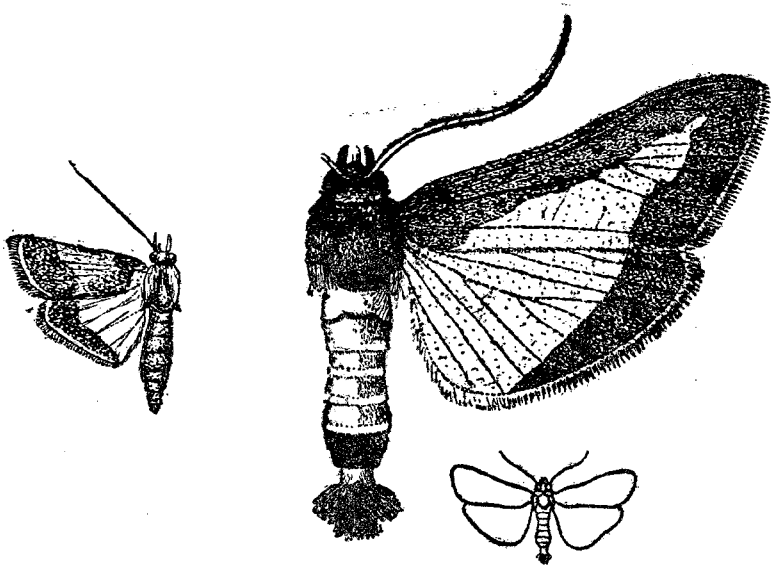


FIG. 207.—MOTH OF PUMPKIN CATERPILLAR.
(*Margaronia indica*, S.)

[*From S.S.I.*]

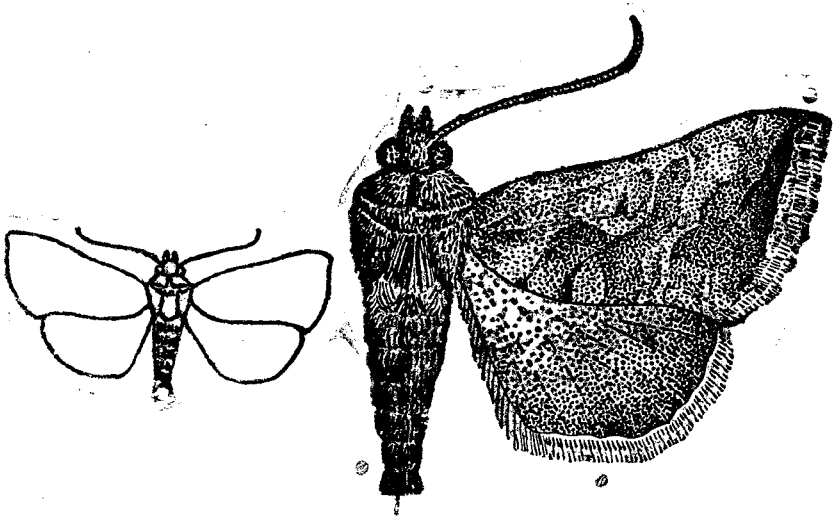


FIG. 208.—MOTH OF SNAKE GOURD SEMILOOPER.
(*Phytometra peponis*, F.)

[*From S.S.I.*]

The snake gourd semilooper (*Phytometra peponis*, F., fig. 208). This is another leaf-eating caterpillar more commonly found on the snake gourd plant. The adult is a stout dark brown moth. The caterpillar is a semilooper with whitish green elongated body. The greenish white spherical eggs which are beautifully sculptured are laid singly on the tender leaves generally on the lower surface. The young larva is greenish and has blackish warts giving rise to hairs. The full fed larva reaches to about an inch and a half in length. The whitish green body has longitudinal pale white stripes and the anal segment is humped. The caterpillar generally cuts the leaf edge and covers the rest of the leaf with this portion and remains feeding inside the fold. Pupation takes place in the same fold in a thin silken cocoon padded with plenty of white silk. Young creepers of snake gourd sometimes suffer considerably, the vines being stripped of all leaves.

In the case of these two caterpillars handpicking is the most effective and economic method of control; the presence of both the caterpillars and their stages can be easily located by the leaf folds and the conspicuous stages of the insects themselves.

The bottle gourd plume moth (*Sphenarches caffer*, Z., fig. 209); the larva of this insect is a very small slender spiny caterpillar found feeding on the foliage of bottle gourd like the brinjal plume moth.

Pumpkin Beetles.—These include both leaf-eating and stem-boring forms; the former are, of course, the commoner ones found everywhere.

Three species of leaf-eating pumpkin beetles are found in the different parts of South India, viz., the red, blue and grey forms (*Aulacophora foveicollis*, F., *A. atripennis*, F., and *A. stevensi*, B.) figs. 192-7 and 210). These are medium-sized active creatures feeding on the foliage and often causing appreciable damage to almost all cucurbitaceous plants. The red and the blue beetles are commoner in the central and southern districts and the grey form is more widely distributed in the Northen Circars. The life history is similar in all cases; the larvæ are underground root feeders and pupate in the soil. These bettles can be collected with nets in the early stages. In badly infested areas stomach insecticides will be found advantageous according to the value of the crop infested.

A stem-boring longicorn beetle (*Apomecyna saltator* fig. 60, 12-14) is occasionally found as a pest on cucurbit vines. This is specially found attacking Dondaikaya (*Coccinia*) plants in the Northen Circars. The pale whitish grubs bore into the main vines and often kill them. The pupa is found in the same burrow. The adult is a white spotted greyish brown longicorn beetle; sometimes

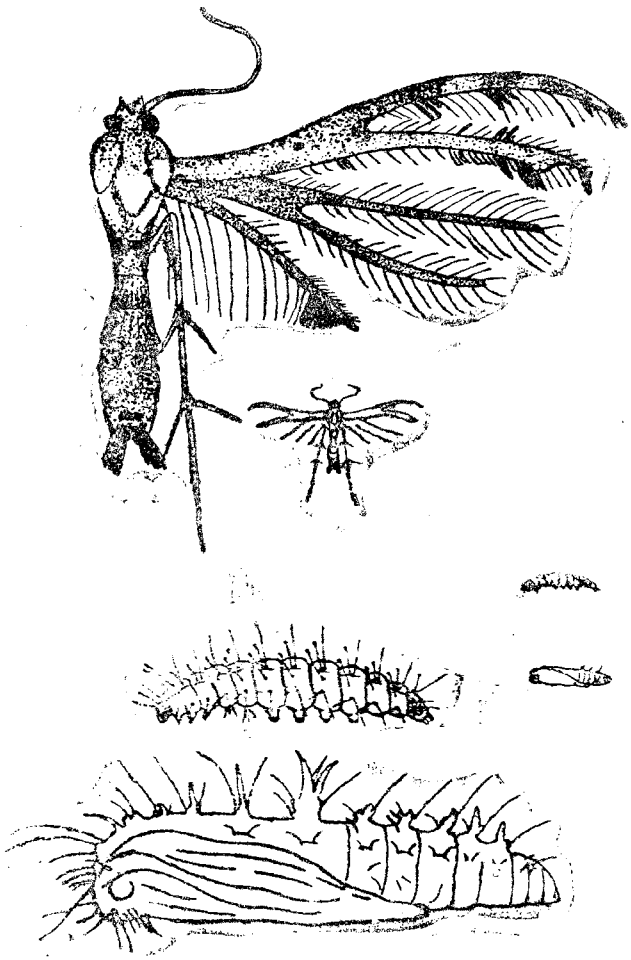


FIG. 209.—BOTTLE GOURD PLUME MOTH.
(*Sphenarches caffer*, Z.)
Larva, pupa and adult.

[*From S.S.I.*]

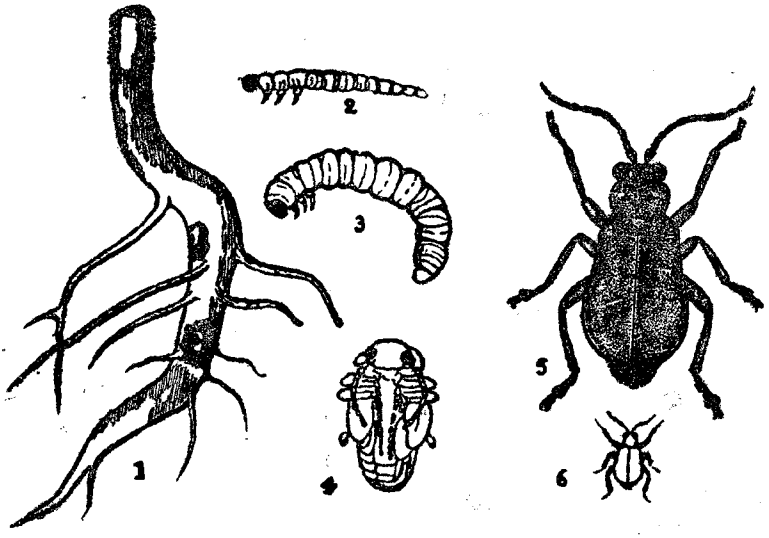


FIG. 210.—THE RED PUMPKIN BEETLE.
(*Aulacophora foveicollis*, K.)
1 Infested plant. 2–6 stages.

[*After Shiraki,*]

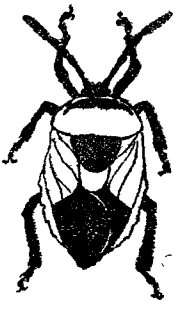


FIG. 211.—PUMPKIN STINK BUG.
(*Aspongopus janus*, F.)

[*From S.S.I.*]

a closely allied species (*A.perotetti*) is also found. This insect can be checked only by early detection and prompt destruction of early infested vines; the beetles when found can also be destroyed. A small dark weevil (*Acythopius citr ulli*, M.) has been noted in the Ceded districts boring into ripening melon fruits but it has not as yet proved of any importance.

STINK BUGS.—Two species of stink bugs (*Aspongopus janus*, F. fig. 211 and *A. brunneus*, Th.) are frequently noted on pumpkin plants in many places. These are flattish medium sized bugs like the green plant bug (*Nezara*) with the characteristic buggy smell. *A. janus* is reddish with dark markings while *A. brunneus* is a pale brown species. These bugs are sometimes found clinging to the leaves and vines in swarms. The life history is exactly like that of the green plant bug. These are sap-suckers which do not generally cause any serious damage though found in swarms at times, they can be easily collected by nets and killed.

FRUIT FLIES.—(*Dacus and Chætodacus* spp., fig. 212).—Two or more different species of these insects are commonly met with on all pumpkin fruits. The maggots of these flies bore into the ripening fruits and very often cause appreciable injury; the fruits begin to rot and drop. The life history of all these flies is similar. Shining whitish cigar-shaped eggs are thrust into the skin of the ripening fruit; these hatch into footless maggots which feed on the fruit pulp by burrowing into it and damage the same; when full fed they generally drop to the soil, change into seed like pupae under the soil and emerge as flies after a week or ten days. These flies can be easily distinguished from ordinary flies by their triangular shaped abdomen and spotted wings. The maggots have the habit of jumping into the air. Fruit fly control consists in preventive measures only. Damaged fruits should be promptly destroyed and the flies trapped by poisoned syrups to prevent egglaying. Fruit flies can also be trapped by such attractive substances as citronella oil, vinegar, dextrose, acetic and lactic acids, etc., etc. All cucurbits, especially melons and bittergourds suffer from these flies, especially from the species in fig. 212. One species *D. brevistylus* is often noted as a bed pest of *Coccinea* plants in Northern Circars.

PLANT LICE.— *Aphis gossypii*, K. and other species are occasionally found on the tender parts of all these cucurbitaceous plants.

GALLFLY.—The bittergourd plant is in some places found developing galls along its distal shoots; these galls appear as elongated thickenings of the vine; inside the gall are found maggots of a gall fly (*Lasioptera falcata*, F.) a slender dark brown mosquito like insect. The injury has not, however, been found to affect the crop very seriously, fig. 213.

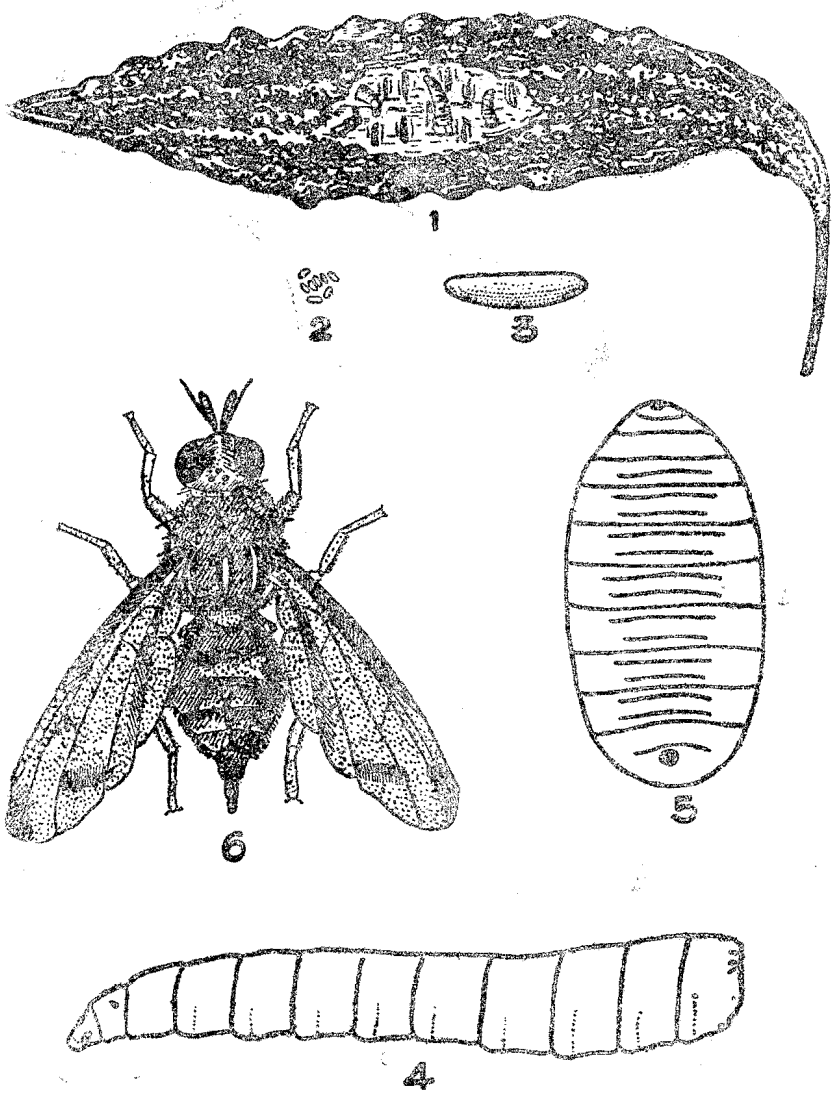


FIG. 212.—CUCURBIT FRUIT FLY.
(*Chaetodacus cucurbitæ*, C.)

1 Attached fruit. 2–6 stages of fly.
[4–6 *after Dammarman.*]

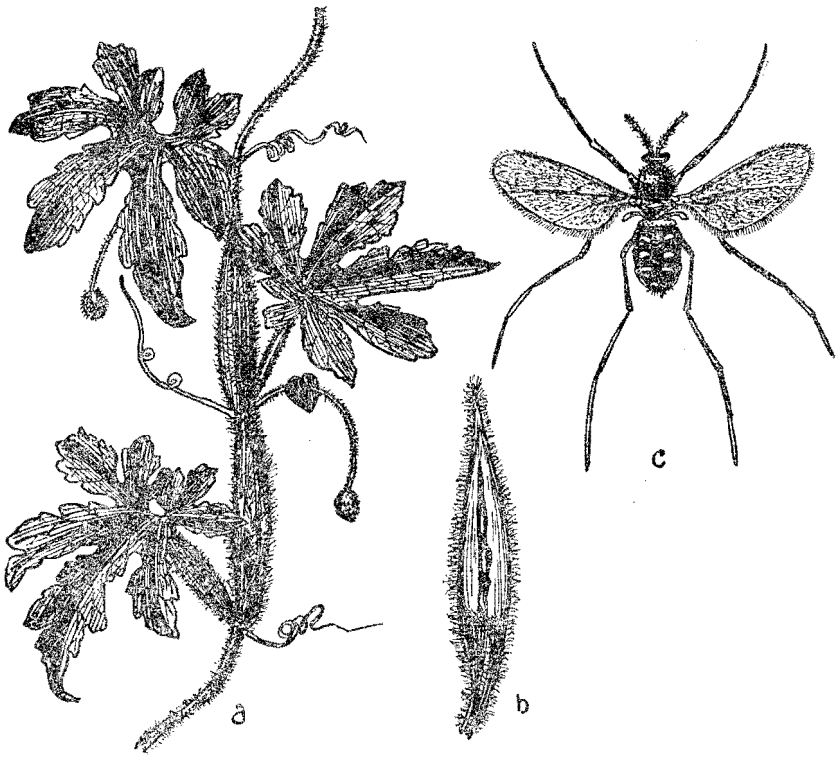


FIG. 213.—BITTER GOURD GALL FLY.
(*Lasioptera falcata*, F.)
a Shoot with galls. *b* One gall opened. *c* The fly.

Among recently noted minor insects on cucurbits mention may be made of a very small dark weevil (*Baris* sp.) feeding on the tender shoots of snake gourd in Tanjore and the brownish green moquito bug (Capsid of tobacco, fig. 285) found feeding on the same plant in Cochin.

AMARANTHUS.

This common leaf vegetable is troubled by comparatively few insects. One of these is the Amaranthus weevil (*Hypolixus truncatulus*, Fb., fig. 214) almost a specific pest of this plant. The grub of the weevil bore into top shoots and stem; and produce gall-like thickenings. The insect is a medium-sized ashy dark grey weevil; both the adult and the young ones attack the top shoots just like the cotton shoot weevil (*Alcidodes affaber*, F.) and the life history and habits are also exactly similar to the latter. The insect attacks both wild and domesticated species of amaranthus, but chiefly the variety allowed to grow with stem and not

on the leaf variety. The same preventive measures as those against the cotton shoot weevil should be employed. Wild amaranthus plants growing in the vicinity should be removed to prevent breeding and multiplication of the pest during the off-season.

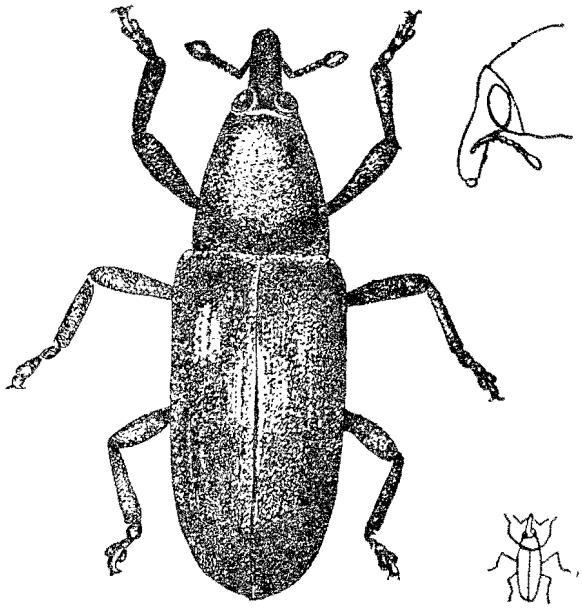


FIG. 214.—AMARANTHUS WEEVIL.

(*Hypolixus truncatulus*, Fb B.)

[*From S.S.I.*]

Frequently the foliage of all varieties of Amaranthus is affected by a slender green leaf caterpillar (*Hymenia fascialis*, C., fig. 215); it often folds the leaves and top shoots also. The moth is easily made out by its dark wings having wavy white markings. The insect breeds on grasses and is generally found flying about during day time among grass and low vegetation. The folds of the first attacked plants can be collected and destroyed to prevent further attacks. Among minor insects noted on Amaranthus are, a shining tortoise beetle (*Cassida exilis*, B.), plant lice, the onion and chillies caterpillar (*Laphygma exigua*, H.), and species of scale insects (*Lecanium hesperidum* L. and *Pulvinaria durantæ* T.).

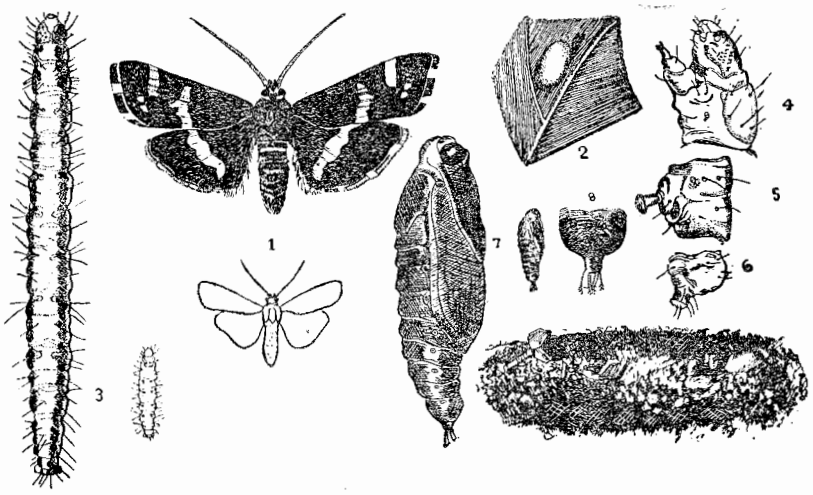


FIG. 215.—AMARANTHUS CATERPILLAR—STAGES.

(*Hymenia fascialis*, C.)

[2–9 *after Marsh*—1—*S.S.I.*]

Onions and Garlic.

The most important and rather serious pest of these two crops is the onion thrips (*Thrips tabaci*, L., fig. 192–10), an insect which is found all over the world; on onions it is occasionally found accompanied by the banded groundnut thrips (*Heliothrips indicus* B.) also. These are minute insects with fringed wings found in numbers on the foliage lacerating the tissue and sucking the sap. In bad infestations whole plants appear blighted and occasionally dry up as though for want of water. This species exists almost everywhere and it is found sometimes serious on garlic in parts of Bellary where this valuable crop is specially grown. Of the different control measures tried so far, the use of tobacco either as dust or decoction has been found very satisfactory. Recently B.H.C. spraying has given spectacular results. Cultural methods like regular irrigation or periodical harrowing of the plot also produce good effects in making the plants resist the pest to a great extent. Frequently the polyphagous leaf caterpillar (*Laphygma exigua*, H., fig. 83-III) is found on the onion crop and this can be hand-picked; only the preventive method of clipping off the infested leaves can be adopted when such caterpillars remain inside the hollow tubular leaves of onion and garlic plants. The tobacco caterpillar (*Prodenia*) is also found sometimes on these plants.

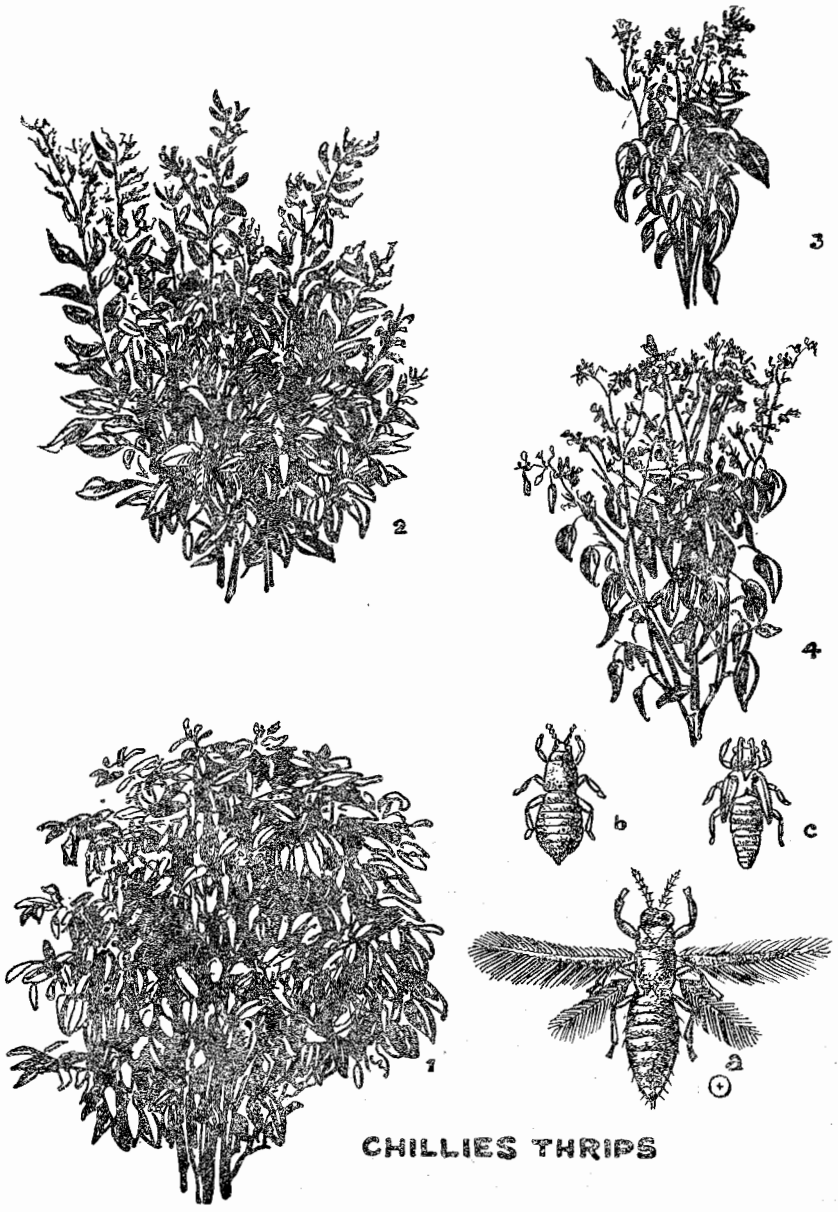


FIG. 216.—CHILLIES THRIPS.

(*Scirtothrips dorsalis*, H.)

1, 2, 3 & 4 Plants healthy and affected.

a, *b* & *c* Stages of thrips.

Chillies.

As in the case of onions, the chillies crop also suffers mainly from "thrips" though the commonest species found on this plant in South India is another (*Scirtothrips dorsalis*, H. fig. 216). Though widely distributed in South India it is noted to do serious harm only in areas where the plant is cultivated as a dry crop, as in the Guntur and Godavari upland tracts; it is also occasionally serious in parts of the Madura and Coimbatore districts. The same remedies may be adopted as for *thrips* on onions. The seedlings may be treated with tobacco before transplantation from the nurseries. The same leaf caterpillar (*Laphygma exigua*, H.) found on onions occasionally appears on chillies also; this rarely causes serious harm, fig. 203–2.

Occasionally the stem-borer of brinjal (*Euzophera perticella*, R.) is found attacking chillies stem but has never been found on any large scale. Chillies plants in parts of Northern Circars are often attacked by chafer beetle grubs which feed on the under-ground roots and sometimes kill tender plants.

Garden Peas.

On this crop which is not extensively grown in South India, the chillies caterpillar *Laphygma* and the snake-gourd semilooper (*Phytometra*) have been noted so far.

Colocasia.

Very few insects are found on this plant, and of these, the leaf-eaters are the most important. The tubers have not so far been found attacked by insects. Among leaf-eaters, the common ones are the following—The white spotted flea beetle (*Monolepta signata*),

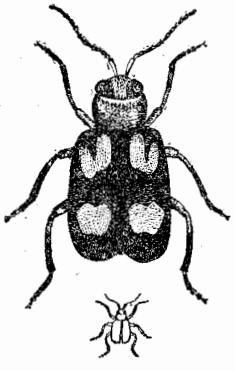


FIG. 217.—COLOCASIA FLEA BEETLE.

(*Monolepta signata*, Ol.)

[*From S.S.I.*]

O. fig. 217); a small active beetle biting holes on the leaves causing some damage to the foliage. Among caterpillars noted are the tobacco caterpillar (*Prodenia litura*, F.) and a sphinx caterpillar (*Hippotion oldenlandiæ*, F.); the former is the well-known polyhagous creature already noted on castor and the latter is a stout big caterpillar with the characteristic horn on the anal segment. The habits of this insect are exactly like the green gram or lablab sphinx caterpillars. Another horned caterpillar (*Rhyncholaba actens*, C) is also noted on this plant. These leaf pests can be checked in bad cases by dusting B.H.C. or D.D.T. or arsenate powders. The groundnut thrips (*Heliothrips indicus*, B.) and lace wing bug (*Stephanitis typicus*, D., fig. 247) are also found on the tender foliage in some places but only as minor insects. A species of plant lice (*Pentalonia galadii*, D.) is sometimes found infesting this plant. A small grasshopper (*Gesonia punctifrons*, S.) has been noted to burrow the stems of this plant and thrust the egg-mass into the succulent tissue, and the young ones are found feeding on the plant. This habit is curious among such grasshoppers which lay eggs generally in the soil.

Elephant Foot Yam *

The foliage of this plant occasionally becomes subject to the attacks of a red and black spotted leaf beetle (*Galerucida bicolor*, H.) and one or two species of horn worms as in *Colocasia*, such as *Hippotion celerio*, L., *Rhyncholaba actens*, C., etc. The larvæ of the leaf beetle are found feeding gregariously on the leaf tissue. It has been noted only in the Northern Circars and Malabar till now and rarely as a serious pest.

Koorkan †

This plant is commonly grown in the West Coast area for its tubers, which are used as vegetable like potatoes, yam, etc., ; two leaf-eating pyralid caterpillars have been noted by the author doing some damage to the plants. One (*Pycnarmon cribrata*, F.) is a pale whitish moth the larva of which folds single leaves, and the other (*Phostria piasusalis*, W.) a pale brown moth the larva of which folds the top shoots. The former is sufficiently checked by a braconid parasite (*Microgaster psarae*, W.).

Dioscorea.

This climber, the underground tubers of which are used like sweet potatoes and yams and which is cultivated all along the West Coast has been found attacked by two insects so far though not as serious pests. One is a saw fly (*Senoclia dioscoreae*, R.,) noted in South Kanara and the other is a skipper butterfly caterpillar, both attacking the leaves.

* Amorphophallus campanulatus.
† Coleus parviflora.

Curry Leaf Plant.*

This plant, the leaves of which are used in Indian homes for vegetable and spicing purposes, is subject to two insects which are pests of citrus trees also—one is the orange butterfly (*Papilio demoleus*, L., fig. 233–2) and the other a small shoot bug (*Diaphorina citri*, K.). The former (see under *citrus*) feeds on the leaves. The latter is a small greenish brown-active jumping bug (*Psyllid* which appears in swarms like plant lice, sucks up the juice from the tender parts and allows them to fade and dry. This kind of damage is sometimes very appreciable. The caterpillar can be checked by hand picking the larvæ and collecting the butterfly which is easily made out by its black and yellow markings. For the bug, a contact insecticide like tobacco decoction may be found necessary in bad cases. This bug is occasionally found on citrus shoots also.

Tomato.

The well-known pests of this plant in South India are the tobacco caterpillar (*Prodenia*), the Epilachna beetles (*Epilachna* spp.) and the tailed mealy bug (*Ferrisiana virgata*, F., fig. 218). The tobacco caterpillar is often very destructive to the leaves, shoots and fruits; occasionally the gram caterpillar (*Heliothis*) is also found boring into the fruits in company with this caterpillar. Epilachna beetles sometimes completely remove the green matter from the foliage allowing the plants to fade and dry. Hand-picking in the early stages and application of stomach insecticides in bad cases will be found effective. For the mealy bug which sometimes covers whole plants in white patches, pruning, of badly infested leaves and shoots and application of contact insecticides will be effective. Tomato plants have been found in some places subject to the attack of fruit-sucking moths (*Othreis* spp.) which are specific pests on oranges (see p. 281). The tobacco capsid (*Engytatus*, fig. 285) is also found on tomato occasionally.

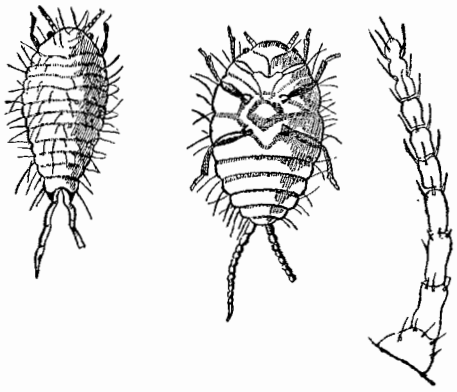


FIG. 218.—TOMATO MEALY BUG.
(*Ferrisiana virgata*, C.)

* Murrayia koenigi.

CRUCIFERAE (*Cabbage, Radish, Cauliflower, etc.*)

The insects affecting most of these temperate region vegetables are more or less similar. These include a sawfly, some leaf-eating and boring caterpillars, cutworms and bugs including plant lice and stink bugs. Of these, the caterpillars feeding on the foliage and boring into the stems and buds are more serious.

THE MUSTARD SAWFLY (*Fig.* 219-4)—(*Athalia proxima*, K.).

This is one of the very few hymenopterous insects found as crop pests in India. The adult is a soft dark and red wasp slightly bigger than a honey bee. The young one of this creature is a leaf eater and sometimes causes substantial harm to radish, mustard and allied plants especially on the hills and elevated areas like Mysore, Coimbatore, etc.; it is very rarely noted in the plains and that only during the cold weather months.

Life history and habits.—Eggs are thrust into the plant tissue and the young greenish grey larvæ hatching out of these feed on the foliage and grow to about an inch or more. These larvæ are uniform dark grey to black in colour and resemble caterpillars of lepidoptera but can be easily recognized by the presence of eight pairs of prolegs. The full fed larva about $\frac{3}{4}$ inch long constructs an earthern cocoon inside which it changes into the pupa.

Control measures.—Hand-picking is very easy and in bad cases and in extensive areas, application of stomach insecticides will be effective.

CATERPILLAR PESTS. These include (1) the cabbage borer (*Hellula undalis.* F.—fig. 219-1).—This insect has a world-wide distribution. In the early stages, the caterpillar mines the foliage and feeds on the shoots but finally it enters the stems or cabbage and burrows into it. The full-fed larva is about 2/3rd of an inch long and has a pale whitish brown colour with three or four longtitudinal stripes. The pupa is found in the burrow, in the leaf folds or even in the soil. The adult is a pale yellowish brown moth with wavy grey markings on the wings. This is an insect often doing serious damage and rather difficult to control, except by well-known preventive measures. (2) The Diamond back moth (*Plutella maculipennis* C., fig. 219-2)—This is also an equally well-known insect enjoying a world-wide distribution. The caterpillar in this case is a small slender pale green one which feeds on the foliage, bites holes and damages the cabbage. Eggs are laid singly on the tender parts of the plant and the hatching caterpillars feed on the foliage and grow to about a third of an inch in length; at this stage the caterpillar has a palegreenish colour with the anterior region pale brown. The pupa is enclosed in a transparent silken cocoon often seen exposed on the foliage of infested plants. The moth is a very small one and has pale white marks on its wings which, when the creature rests, appear together as a diamond shaped median

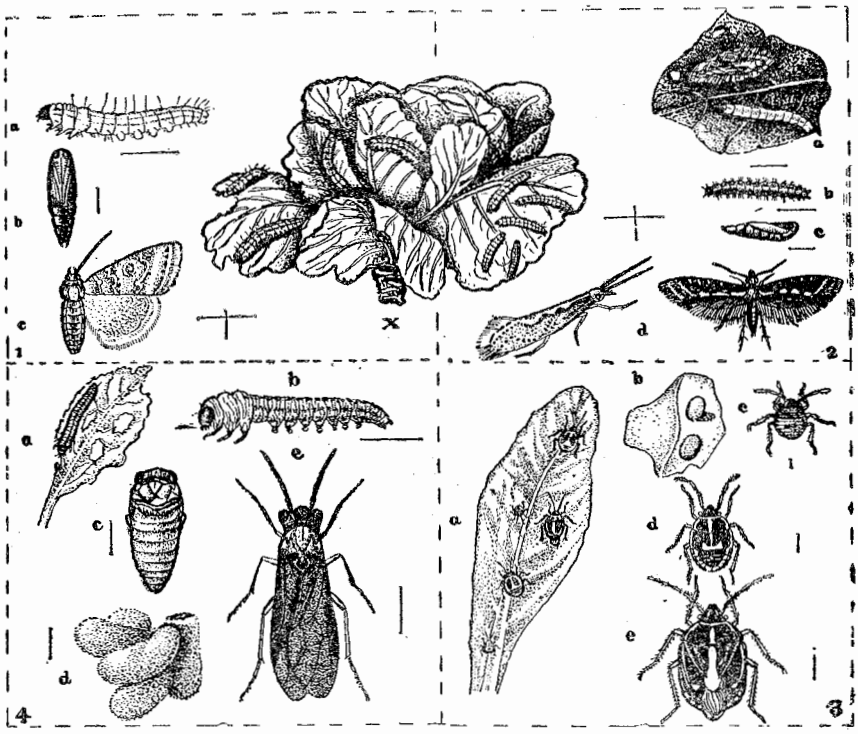


FIG. 219.—INSECT PESTS OF RADISH, CABBAGE, ETC.

1 Cabbage borer (*Hellula*).
2 Diamond back moth (*Plutella*).
3 Cabbage bug (*Bagrada*).
4 Saw fly (*Athalia*).

dorsal patch (hence its name). In bad infestations dusting or spraying of stomach insecticides will give relief. It is safer that such cabbages, etc., are washed thoroughly before being sent to the market or kitchen. (3) The leaf webber caterpillar–This is the larva of a small moth (*Crocidolomia binotalis, Z.*), which feeds on the foliage webbing the leaves. It is common on mustard also. (4) Cutworms (fig. 83)—On the hill regions young plants suffer from different species of cutworm caterpillars (*Euxoa, Agrotis, C.nigrum*, etc.). For details regarding cutworms, see page 122. The semiloopers (*Plusia* spp.), are also sometimes found on these plants.

Small flea beetles of different species (chiefly *Phyllotreta downsei*, B) and *Chætocnema* sp. occasionally appear in numbers and damage the plants by biting small holes on the foliage ; for these the plants may be sprayed with Bordeaux mixture as a deterrent. A specific stink bug—the cabbage bug (*Bagrada cruciferarum*, F., fig. 219–3) is generally noted sucking the sap of all cruciferae. This insect is a dark-brown bug with reddish brown markings. The life history and habits are exactly like the green plant bug

(*Nezara*, page 168). It is sometimes found as a serious pest in parts of Mysore and Deccan. It can however be controlled by D.D.T. or B.H.C.

The onion thrips (*Thrips tabaci*, L) is also sometimes noted on young cabbage, cauliflower and radish plants. A dusting of powdered tobacco will easily check this pest.

PLANT LICE.—Two or three species of plant lice are generally found on these plants; these include (*Myzus persicæ*, S., and *Rhophalosiphum pseudobrassicae*, D.).

As regards control of vegetable pests the modern chemical and mechanical methods will be found advantageous and paying nowadays, especially in kitchen gardens in the suburbs of big cities, in the markets of which vermin free vegetables and fruits will always command a good sale. B.H.C., 5% and D.D.T. spray have been found to be specific for the cut worm and other borer pests.

CHAPTER XVI

Insects Affecting Fruit and Palm Trees.

PESTS OF FRUIT TREES.

Though numerous kinds of tropical fruit trees are found in the different parts of South India very few of them are grown on any extensive areas as in such fruit-growing countries like South Africa, California or Australia. The only fruit crops which are cultivated on a fairly large scale in different tracts and which can be reckoned as important are the mango, the citrus varieties and the banana. The others which rank only next to these three include Guava, Sapota, Melons, Grape, Pomegranates, Jujub, Jak, etc. As regards fruits like Apples, Pears, Peaches, Plums, etc., which are natives of temperate regions, there is very little cultivation of these in South India and this is confined to the hills (Nilgiris, Shevaroys, Pulneys) and the Mysore plateau. The fruit crops in South India are as much subject to insect pests as are the various field crops. They however differ from the latter in that they afford permanent footings to insect pests, being perennial plants ; once an insect gets established on any fruit tree, it is easy for it to multiply right through unlike most field crops which are cleared out at the end of each season. The more important of the insect pests which affect fruit crops in general in South India are the stem borers, leaf, shoot and bark caterpillars and beetles, scales and mealy bugs, leaf hoppers, fruit flies and fruit-sucking moths. There are some other insects also associated with fruit crops but they are generally of minor importance or become sporadic local pests only during certain years.

Mango.*

The Mango Hopper (*Fig.* 220) [*Idiocerus niveosparsus*, L. (1)]. — Among the numerous insects which do harm to the mango tree the "mango hopper" is one of the worst. In certain years this insect appears in numbers in some tracts and causes considerable damage. In many localities, the pest has been noted to do substantial damage year after year. In Madras, the pest is seen at its worst in the well-known mango tracts around Salem, Chittoor and Bangalore. During the cold weather, when the trees put out flower spikes, thousands of hoppers—young and adult—appear and suck-up the juice from the shoots and flower stalks. This drain of the tree sap causes the flowers and buds to dry and wither. When one approaches a badly infested tree, clouds of hoppers move about like mosquitoes and make a rustling noise as they dash against the

* *Mangifera indica.*

1 Two other species *I. clypealis* and *I. atkinsoni* also occur on mango with *I. niveosparsus.*

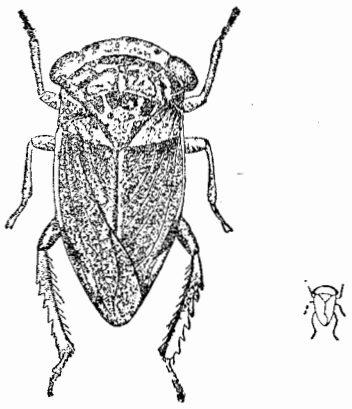


FIG. 220.—THE MANGO HOPPER

(*Idiocerus niveosparsus*, L.)

[*From S.S.I.*]

foliage. The hoppers produce a sweet fluid excretion like the plant lice and this sweet juice thrown out by myriads of these insects after feeding on the tree sap wets the soil around the tree, and thousands of flies, bees and other insects are attracted by this secretion ; in fact, when a tree is badly affected one can notice the juice actually dropping down. When there is a severe infestation, the trees—in fact, the whole garden—presents a sickly sight. The trees are deprived of the buds and blossoms and the leaves appear shiny and covered with a sooty mould ; and thousands of cast skins of the hopper are found on the shoots and leaves. In some trees where the flowering appears very promising early in the season, it often happens that very few fruits are developed. This damage caused by hoppers is known by the name of " honey-dew disease " (*Theni manzu*) in many parts of the Telugu country. The continuous injury done to trees year after year by this pest makes them gradually lose their vigour and in the long run it considerably affects their yielding capacity.

Life history and habits.—The mango hopper is a small creature about an eighth of an inch in length and having a wedge-shaped body. The head is broad with the body gradually narrowing backwards. The legs are well developed, especially the hind pair. The general colour is of a light greenish brown with small markings of black and yellow. The hopper is extremely active in habits and is able both to fly and jump about. It has a tubular sucking mouth part by means of which it punctures the soft portions of the plant. The insect passes its early stages on the mango tree itself. The minute eggs are generally inserted by the parent insect singly into the plant tissue through slits made on the shoots and flower stalks. The small hoppers (or nymphs) hatching out of the eggs are similar

to the parent in most respects. They are very active, move about rapidly along the flower spikes and shoots, and feed on the plant sap; but they are wingless, smaller in size, and unable to fly or jump. When disturbed these crawl away and hide themselves on the lower surfaces of the leaves and shoots. The young ones cast their skin periodically and within a few days grow into adults. On the under-surface of leaves of badly-affected trees patches of these cast skins may be found in abundance side by side with numerous young and adult hoppers. Both young and adult swarm on the tender portions of the tree and suck up the plant juice by means of their proboscis, and cause a substantial drain upon the plants. It is found that the breeding season of the insect corresponds with the time when the mango trees blossom and hence the enormous numbers in which the hoppers are found at this time of the year. The insect is not absent from the trees, however, during the other seasons of the year but is only found in small numbers. The author had noted a reduvid bug (*Isyndus heros*, Fb.) feeding on the hopper as a natural enemy.

Control measures.—To control hopper pests, different measures might be adopted. Two are worth noticing: One is the mechanical method of trapping and destroying the hoppers by means of nets, bags or screens smeared with some sticky material; the other consists in spraying a contact insecticide to kill the young hoppers which are wingless and unable to fly or jump. Against a pest like this which infests grown up trees, the former method will be found rather impracticable, though it may be found effective against a similar insect affecting low-growing crops. On the other hand spraying with an insecticide is not only practicable for the mango hopper but if carried out at the proper time is very effective. To get the best results, spraying must be commenced as soon as the first flower shoots begin to appear. For, it is at this time that the breeding of the insect begins and by the time the blossoms appear, countless numbers of nymphs will be seen on them. Any substance that would kill the nymphs either by irritation or by suffocation can be used. By experience it has been found that the substance called "Fish Oil Rosin Soap" answers this purpose very well. The soap must be mixed thoroughly with water just before the spraying so that the mixture is a thin watery solution. With the utmost economy 2 lb. of soap may be found sufficient for an average-sized tree. Fruit trees should not however be sprayed when in bloom; it not only injures them but also prevents pollination by bees which are killed. Application of sulphur in powder form has also been found effective against this insect in Bombay; this method will also be effective for 'mildew' disease which often appears on the trees together with the mango hopper and causes a sickly white appearance of the blossoms and gradually kills them—vide Jhaveri's Bombay Leaflet of 1930.

The Mango Stem Borer Beetle (*Fig.* 221)—(*Batocera rufomaculata, Dg.*)—Though not so common as the mango hopper this insect

CHAPTER XVI

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Though numerous kinds of tropical fruit trees are found in the different parts of South India very few of them are grown on any extensive areas as in such fruit-growing countries like South Africa, California or Australia. The only fruit crops which are cultivated on a fairly large scale in different tracts and which can be reckoned as important are the mango, the citrus varieties and the banana. The others which rank only next to these three include Guava, Sapota, Melons, Grape, Pomegranates, Jujub, Jak, etc. As regards fruits like Apples, Pears, Peaches, Plums, etc., which are natives of temperate regions, there is very little cultivation of these in South India and this is confined to the hills (Nilgiris, Shevaroys, Pulneys) and the Mysore plateau. The fruit crops in South India are as much subject to insect pests as are the various field crops. They however differ from the latter in that they afford permanent footings to insect pests, being perennial plants ; once an insect gets established on any fruit tree, it is easy for it to multiply right through unlike most field crops which are cleared out at the end of each season. The more important of the insect pests which affect fruit crops in general in South India are the stem borers, leaf, shoot and bark caterpillars and beetles, scales and mealy bugs, leaf hoppers, fruit flies and fruit-sucking moths. There are some other insects also associated with fruit crops but they are generally of minor importance or become sporadic local pests only during certain years.

MANGO.*

THE MANGO HOPPER (*Fig.* 220) [*Idiocerus niveosparsus*, L. (1)]. — Among the numerous insects which do harm to the mango tree the " mango hopper " is one of the worst. In certain years this insect appears in numbers in some tracts and causes considerable damage. In many localities, the pest has been noted to do substantial damage year after year. In Madras, the pest is seen at its worst in the well-known mango tracts around Salem, Chittoor and Bangalore. During the cold weather, when the trees put out flower spikes, thousands of hoppers—young and adult—appear and suck-up the juice from the shoots and flower stalks. This drain of the tree sap causes the flowers and buds to dry and wither. When one approaches a badly infested tree, clouds of hoppers move about like mosquitoes and make a rustling noise as they dash against the

* *Mangifera indica.*

1 Two other species *I. clypealis* and *I. atkinsoni* also occur on mango with *I. niveosparsus.*

in length. Besides mango it has also been recorded among others on jak, rubber and fig trees. Another stem-borer occasionally found is the grub of a small bluish black jewel beetle (*Belinota prasina*, Th.).

Control measures.—Control measures in this case are mainly preventive being a borer. The first infested branches should be cut and the grub inside killed. Beetles whenever found in the garden should be destroyed. When external symptoms are noted in the shape of surface holes or galleries plugged with fibrous powdery matter or heaps of such matter below a tree, the grubs should be extracted through these holes by hooked wires or destroyed *in situ* by injecting dilute kerosene, petrol, naphthalene, chlorosal or carbondisulphide or tar water, and the holes covered with wet clay soaked in tar. Sanitary measures in the orchard by way of cutting off of all dry branches, scraping loose bark from tree stems and not allowing dead trees to remain uncut will go a great way as preventives.

Fruit Flies.—About half a dozen species of fruit flies, chiefly of the genus *Chaetodacus* (fig. 222) have been noted to attack mango fruits in different parts of the Province. A very good percentage of the ripe mangoes in the important mango areas becomes damaged and unfit for consumption due to the damage caused by the maggots of these fruit flies. Though an infested fruit does not always show any clear signs of attack, one can find it out by handling an infested fruit and noting the sickly and yielding surface ; when such a fruit is cut open, numerous white maggots could be seen wriggling in the damaged pulp.

Life history and habits.—The life history and habits of all fruit flies are more or less similar to those of the one described under melon. The commonest species are the different varieties of *C. ferrugineus* such as *dorsalis, incisus, correctus, zonatus* and *versicolor.*

Control measures.—Plant sanitation in the orchards is the most important measure against these fruit flies. Destruction of fallen and badly infested fruits is the most important of these. The marketing of bad fruits helps the easy distribution of the pest from place to place. Other preventives include trapping the flies with poisoned syrup. Another method of controlling fruit fly pests now attempted in some countries is 'Biological control' by the utilization of their natural enemies like parasites (wasps, etc.) and predators. A common fruit fly parasite in South India is a braconid wasp (*Opius*).

Besides the flies attacking the fruits, mango shoots and buds often suffer from the attacks of gall flies especially along the West Coast area ; those noted are *Dasyneura mangiferae* F. and *Rhabdophaga mangiferae* M. The maggots of these produce galls on the buds and leaves.

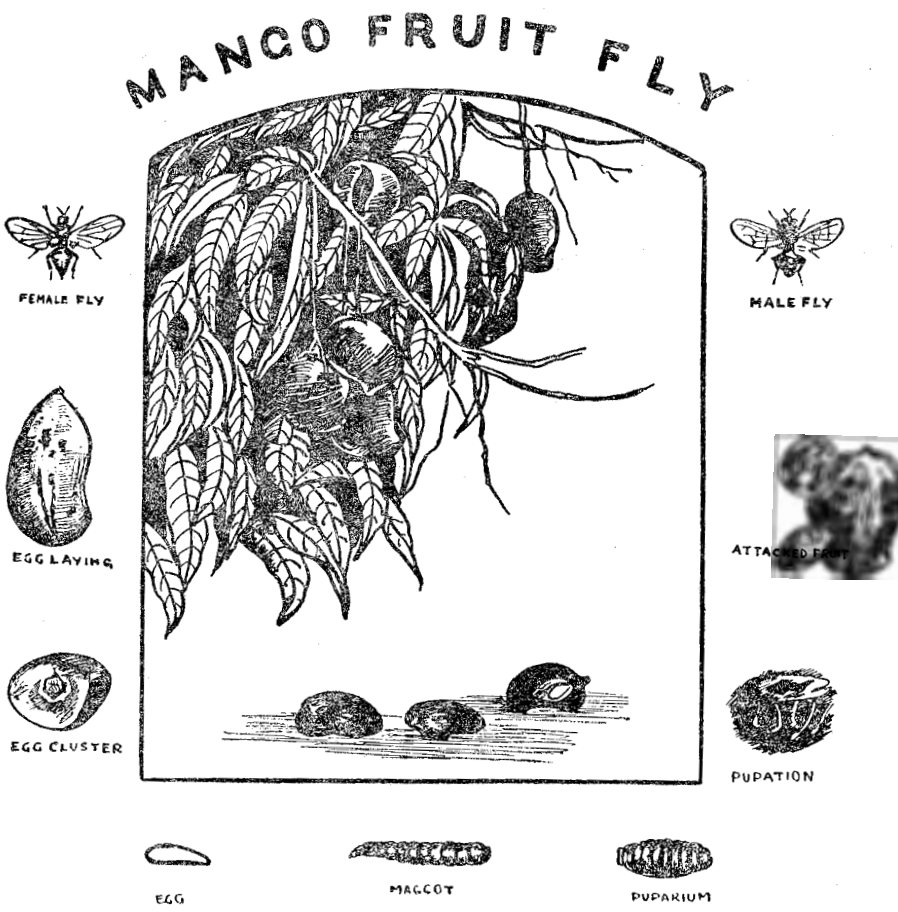


FIG. 222.—THE MANGO FRUIT FLY.

(*Chætodacus ferrugineus* H.).

CATERPILLARS.—The shoots and foliage of the mango tree have been found to be the food of numerous caterpillars ; of these, however, only a few prove to be pests of any real importance. Among these there are representatives of the different categories of leaf eaters noted on page 126 before. These include leaf miners, leaf rollers and folders, shoot borers and hairy and spiny caterpillars. The more important of these are (1) the castor slug(*Latoia Parasa*) *lepida*, G., fig. 223) already noted under castor, (2) the tussock caterpillar (*Porthesia scintillans*, W.) referred to under gogu, (3) a shoot webbing caterpillar (*Orthaga exvinacea*, H., fig. 224) ; this is a slender pale green caterpillar which occasionally becomes serious and on trees infested with it numerous webbed and dry top shoots are conspicuous. Such an attack in many cases prevents flower formation,

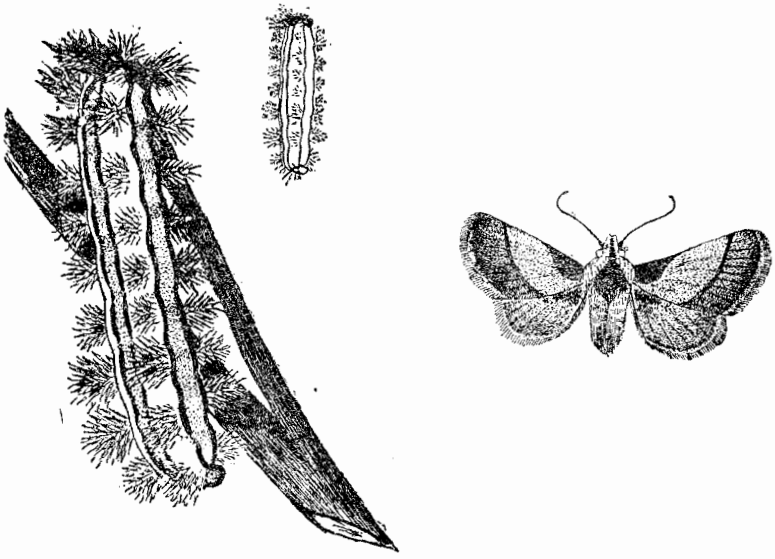


FIG. 223.—THE SLUG CATERPILLAR ON MANGO AND MOTH.
(*Latoia lepida*, C.) [*From S.S.I.*]

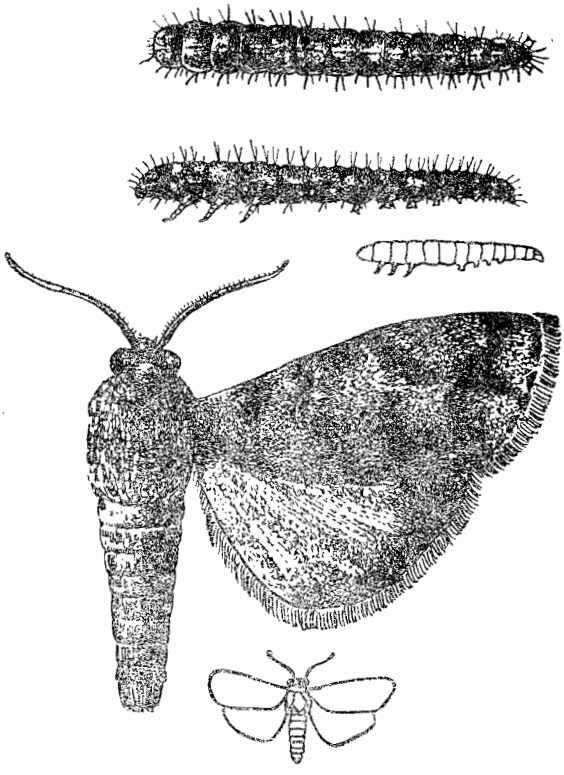


FIG. 224.—THE MANGO SHOOT WEBBER CATERPILLAR AND MOTH.
(*Orthaga exvinacea*, W.) [*From S.S.I.*]

(4) a small shoot boring caterpillar (*Chlumetia transversa*, W.), (5) a green striped and spotted caterpillar feeding on the leaves (*Bombotelia jocosatrix*, G., fig. 225) the larva of a blackish moth, (6) a very slender leaf mining caterpillar (*Acrocercops syngramma*, *M.*) producing blister marks on the tender foliage. Other caterpillars occasionally noted on mango in South India are the leaf webber (*Macalla moncusalis*, W.), the flower attacking forms *Eublemma anguilifera*, M., and *Argyroploce aprobola*, *Phycita umbratelis*, H., *Chloroclystus sp.* and the larvæ of the butterflies *Euthalia garuda*, M., and *Rapala melampus* Cr. When any of these pests appear in a serious condition both mechanical and insecticidal methods will have to be employed—the insecticides useful being stomach poisons.

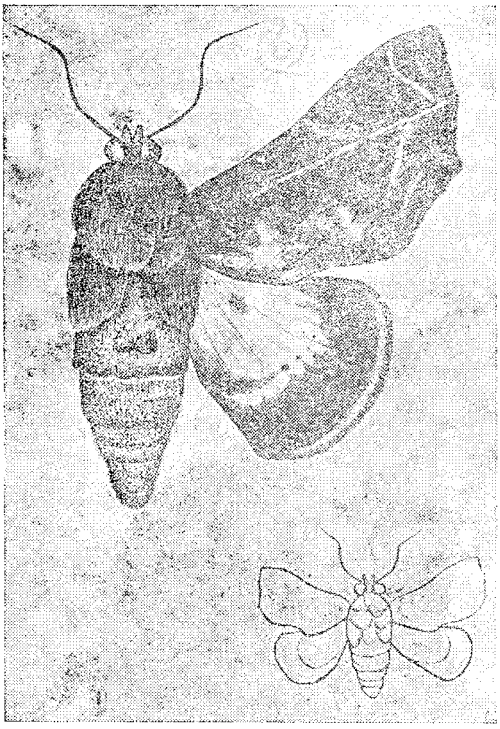


FIG. 225.—MOTH OF MANGO LEAF CATERPILLAR. (*Bombotelia jocosatrix*, G.) [*From S.S.I.*]

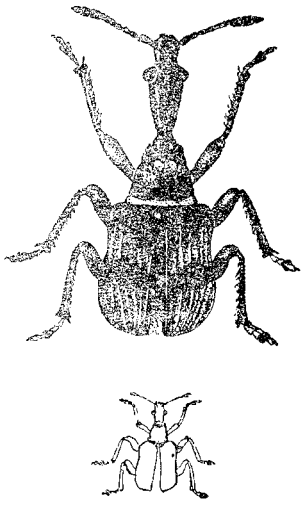


FIG. 226.—THE LEAF TWISTER BEETLE. (*Apoderus tranquebaricus*, F.) [*From S.S.I.*]

MANGO LEAF AND NUT BEETLES.—Of the leaf beetles, there are three having distinct habits of their own—(1) The leaf twisting weevil (*Apoderus tranquebaricus*, F., fig. 226)—This is the commonest of the three and has the habit of twisting the mango leaves into a knot inside which the earlier stages of the insect are passed. This

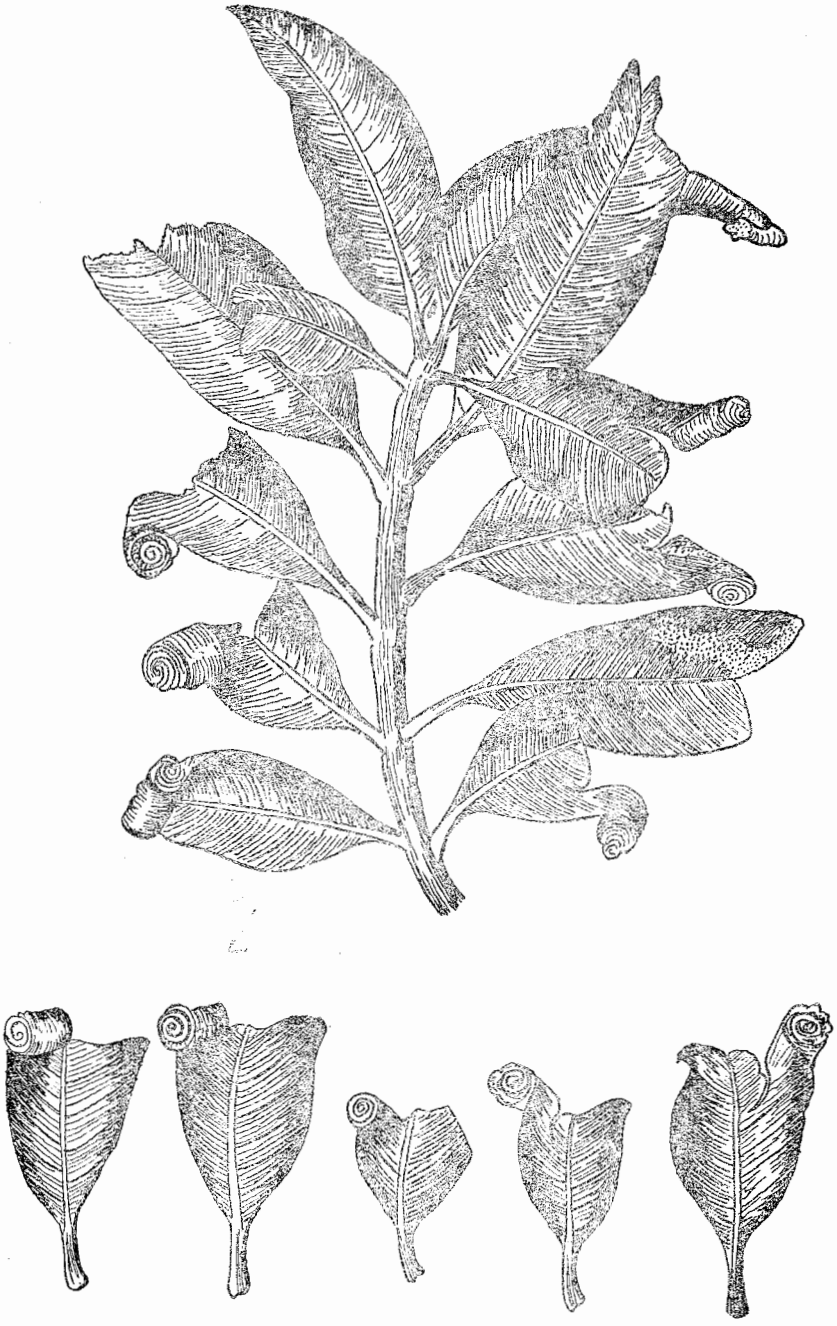


FIG. 227.—WORK OF THE LEAF TWISTER ON MANGO.

is a medium sized reddish brown insect with a long neck. It is also noted on the country almond tree (*Terminalia catappa*). (2) A small leaf tip cutting greyish green weevil (*Eugnamptus* (*Deporaus*) *marginatus*, P., fig. 228) with a long beak. (3) A minute leaf mining weevil (*Rhynchœnus mangiferœ*, M., fig. 229). In these cases the conspicuous leaf knots and folds can be picked and destroyed with the insect. Weevils can also be 'jarred' (infested branches being shaken) over pans of water mixed with kerosene. Insecticidal methods may not generally be found necessary. The mango nut weevil (fig. 230)—*Cryptorhynchus mangiferœ*, M.).—This is a short stout built ovoid dark brown weevil found inside ripe mango fruits generally inside the nut and sometimes burrowing into the pulp. It has a very wide distribution all over the tropics. The insect appears to be partial to certain varieties of mango and is not a serious pest. *Life history and habits.*—Tiny whitish eggs are laid just under the rind of the ripening fruit after an incision is made on the skin. The incision where the egg is laid heals up and for all outward appearance the fruit appears unaffected. The footless yellowish white grubs burrow their way through the developing pulp into the hardening nut. Pupation takes place inside the nut

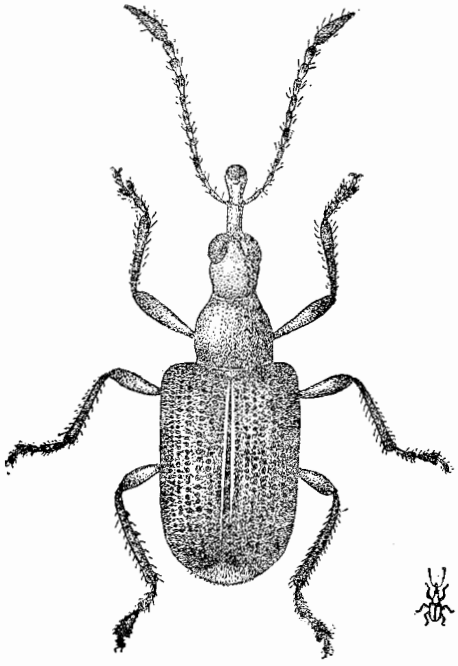


FIG. 228.—MANGO LEAF CUTTER WEEVIL.
(*Deporaus marginatus*, P.)
[*From S.S.I.*]

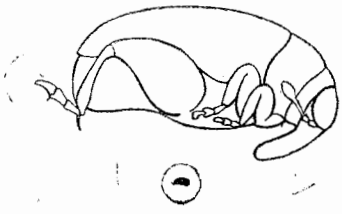


FIG. 229.—MANGO LEAF MINER WEEVIL.
(*Rhynchœnus mangiferœ*, *M.*)
[*From S.S.I.*]

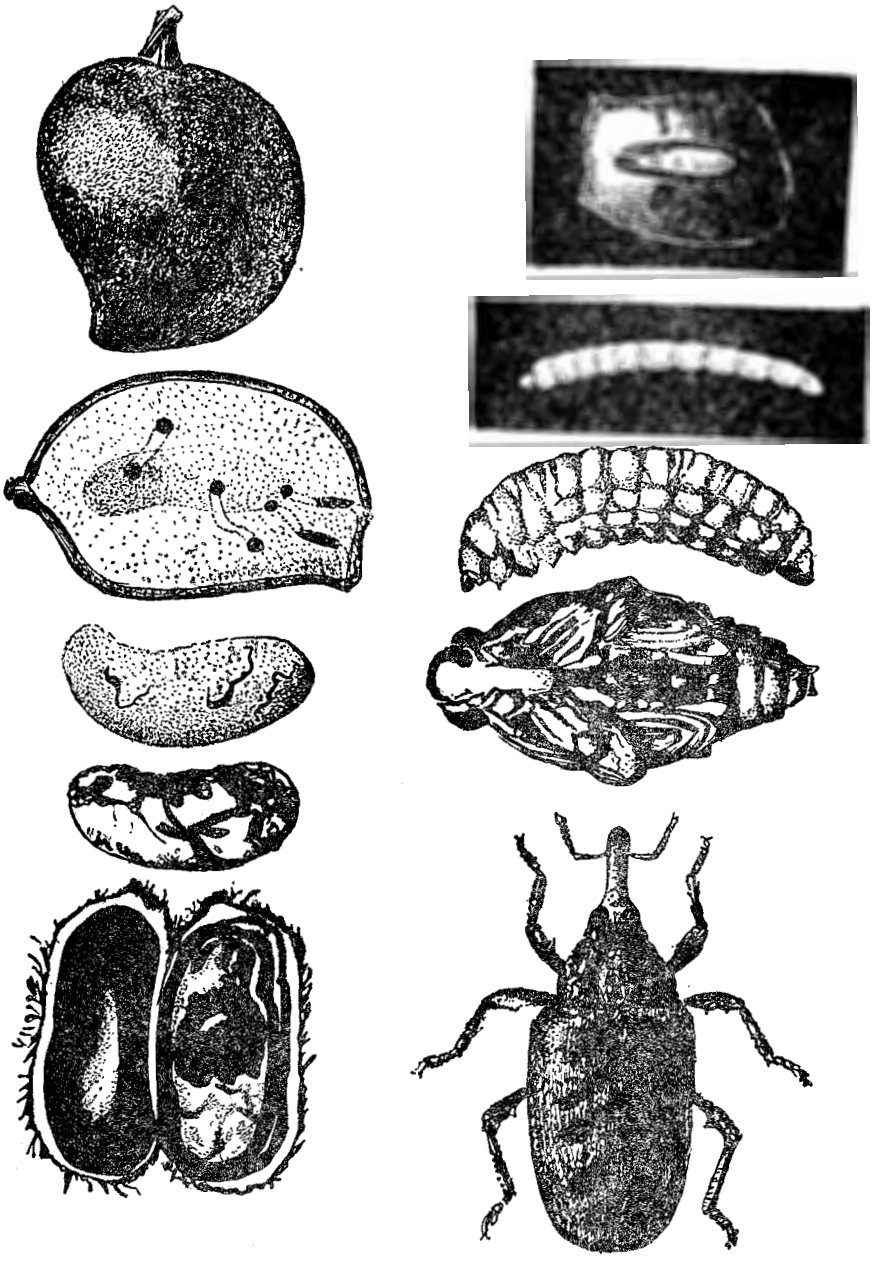


FIG. 230.—THE MANGO NUT WEEVIL.
(*Cryptorhychus mangiferæ*, *F.*)
Work on mango-fruit and stages of the insect.

in a pupal cell and the adult emerges cutting its way out through the latter. The life-history is found to occupy about 40 to 50 days, the whole development passing inside the nut. Though the insect develops inside the fruit the injury to the fruit pulp is not so very marked since the incision made for egg-laying and the narrow passage of the grub into the nut become closed up as the fruit ripens. It has not so far been found to attack any other fruit. Preventive measures alone are possible in this case. The proper disposal of all refuse seeds and fallen mangoes, destruction of the weevil when seen in the garden and general cleanliness will go a great way in checking the pest. Among other beetles attacking mango are chafers (*Anomala* spp.), leaf weevils (*Myllocerus* spp.) and two leaf beetles (*Chlamys* spp.) reported from Travancore.

SCALES, MEALY BUGS, HOPPERS, ETC.—Mango trees, like various tropical fruit trees, are subject to numerous insects of the family Coccidæ (scales and mealy bugs). These include armoured or hard scales, soft scales and mealy bugs. All these have the same habit of appearing in colonies on the tender parts of the plant, sucking the sap and affecting the vigorous growth and appearance of the different parts of the tree. The chief of these pests found in South India are—(1) The mango leaf scale (*Chionaspis vitis*, G.), a whitish hard scale which covers tender leaves, turns them yellow and makes them fade (fig. 231). (2) The guava mealy scale (*Pulvinaria psidii*, M., fig. 238). This soft green scale which is a specific pest of guava occasionally covers mango leaves also ; the pale green insects and the whitish mealy egg sacs are often conspicuous. (3) The other soft scales found on mango include about half a dozen species of the well-known genus *Lecanium* (chiefly *L. adersi*, N., and L. *mangiferæ*, G.). These cover the tender leaves and shoots and suck the

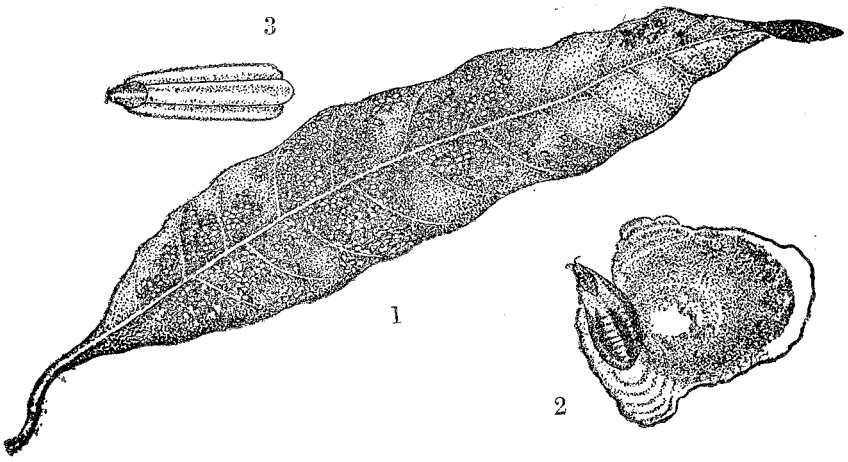


FIG. 231.—SCALE INSECT ON MANGO LEAF.
(*Chionaspis vitis*, G.)
1 Scales on leaf, 2 Female, 3 Male scale.

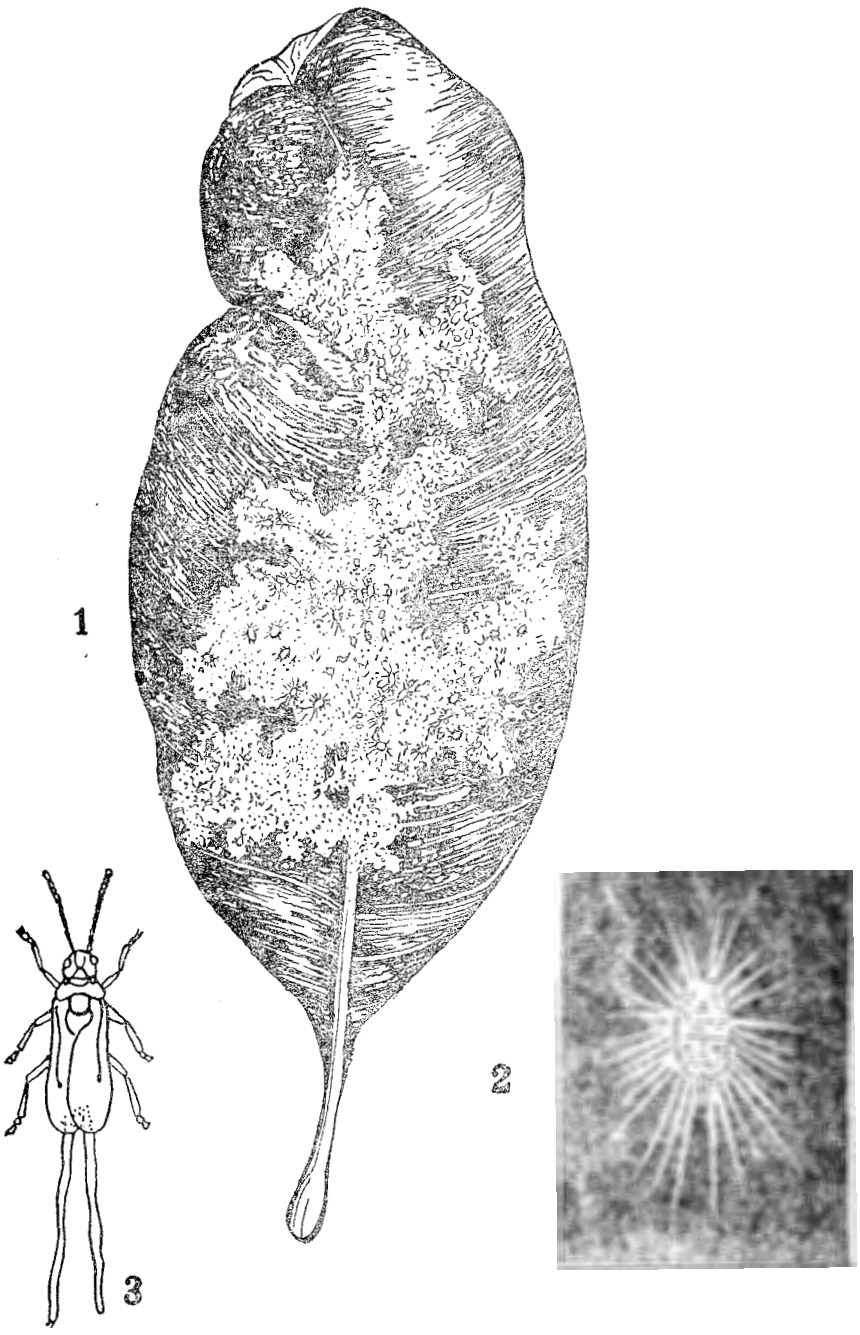


FIG. 232.—MEALY BUG ON MANGO.
(*Phenacoccus mangiferæ*, G.)

1 Leaf with insects. 2 Female enlarged. 3 Male enlarged.

sap. (4) Mealy bugs chiefly (*Phenacoccus mangiferæ*, G., fig. 232, and P. *iceryoides*, G., fig. 327). These two insects which are characterized by their profuse white mealy secretion, sometimes infest mango trees very seriously, covering fruits, tender leaves and shoots. (5) A jumping bug (*Apsylla cistellata* B.) occasionally infests tender leaves often producing coneshaped galls. (6) A small stink bug (*Coptosoma nazirœ*, A.) is sometimes found on the tender shoots also.

Control measures.—Scales and mealy bugs are persistent and perennial pests and are specially partial to fruit trees among cultivated plants. As such, special attention should be paid to their control. In addition to the prompt pruning and destruction of badly infested shoots, contact insecticides suited to the different categories of these insects will keep the pests under control ; hard scales would need insecticides like rosin compounds, while soft ones and mealy bugs could be checked with such washes as crude oil emulsion, fish-oil soap, etc. It may also be added in this connexion that fruit growers have to guard against ants of different kinds which visit some scale insects for their sweet secretions and which also act as media in transporting these scale insects from tree to tree.

The Red Ant (*Fig.* 88) (*Oecophylla smaragdina*, F.).—This notorious and very familiar ant is found on almost all fruit trees throughout the province and is a regular nuisance in orchards. It builds its leaf nest on the trees and moves about in long trains all over the tree branches. Though the insect does not directly cause any harm to the fruit tree, indirectly it creates a good deal of trouble. In the first place, it acts as a distributing agent of the different kinds of noxious scales and mealy bugs mentioned before from plant to plant and these sucking insects colonise themselves on the trees and start their injurious work. Secondly, the presence of the ant is annoying since it stings severely persons who disturb them.

Control measures.—The radical control of this ant consists in destroying the nests by burning them with torches during night time. Another method would be to treat the nests either with calcium cyanide or B.H.C. or D.D.T. Contact insecticides may be sprayed on scale and mealy bug infested shoots visited by these ants and the trunks of trees can be banded with tar or a sticky paste to prevent ants going up the trees.

Citrus (*Orange, Lime, Lemon, Pomelo, etc.*).

The important pests of citrus varieties grown in different parts of the province are, as in the case of mango, the boring larvæ, leaf and bark caterpillars of sorts, scales, mealy bugs and mealy wings

and the fruit sucking moths; the others including leaf hoppers, plant lice, stink bugs, etc., are of minor importance or appear sometimes only as sporadic local pests.

THE CITRUS STEM BORER BEETLES (*Fig.* 233-3),—These are generally longicorn beetles belonging to the same group as the mango stem-borer beetle and have the same habits. Over half a dozen species are known from different parts of India. In South India, two important species have been noted so far. One is a shining steel-blue beetle (*Chloridolum alcamene*, T.).

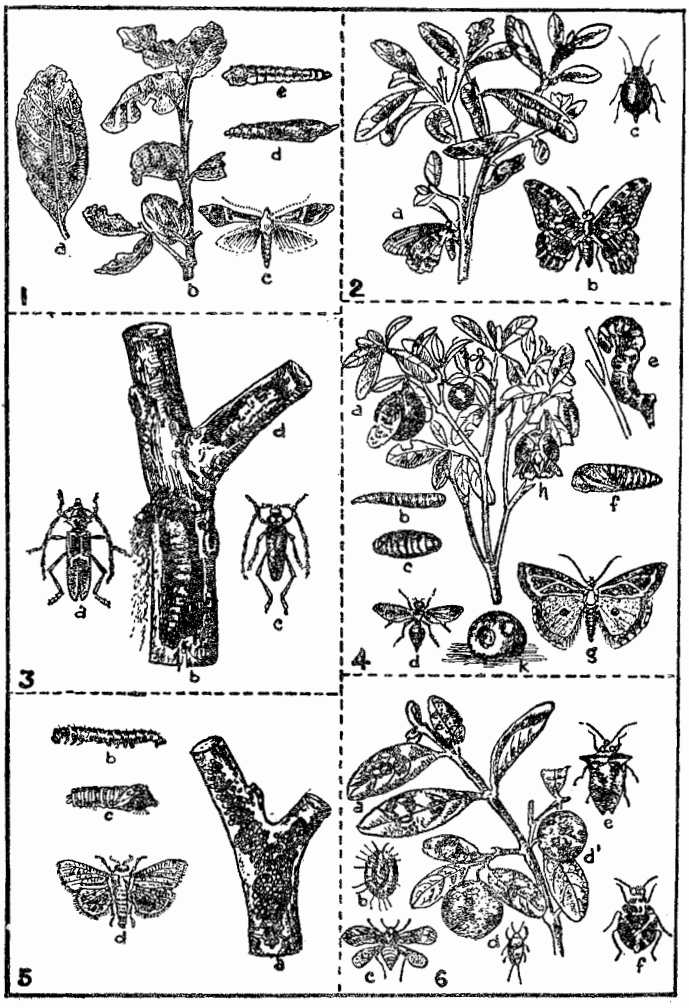


FIG. 233.—SOME CITRUS INSECTS OF SOUTH INDIA.

1 The leaf miner (*Phyllocnistis*).
2 The leaf butterfly (*Papilio*) and Aphis.
3 Stem borer beetles (*Chloridolum* and *Chelidonium*).
4 Fruit flies and fruit sucking moth (*Chœtodacus and Othreis*).
5 Bark borer (*Indarbela*).
6 Stink bugs and mealy wings.

This pest has been noted in Coorg, Wynaad and a few other places. The other a closely allied species (*Chelidonium cinctum*, G.) found in Chittoor, Salem and other tracts is a slightly bigger insect with a yellowish patch on each upper wing. Another one is a dark blue jewel beetle (*Belinota prasina*, Th.) which is also noted occasionally on mango.

Control measures.—Same in the case of the mango and other tree stem borers.

THE SHOOT AND BARK BORER (*Fig.* 233-5)—(*Indarbela tetraonis*, M.).—The borer in this case is a caterpillar which bores into the shoot and also into the bark. The adult insect is a short stout built pale brown moth with wavy grey marks on the wings. The presence of the pest on an infested tree is indicated by the winding galleries of powdery matter webbed together on the bark, and at the region of the shoots, forks and other parts of the tree stem. The insect is occasionally serious. On citrus it is often bad in parts of Kurnool, Cuddapah and the Northern Circars.

Life history and habits.—The parent moth lays eggs under loose bark or in wounds on the same and the hatching caterpillar bores into the stem and bark; it moves about in a gallery of powdered bark and silk, feeds on the bark and also enters the stem in some shoots. The caterpillar when full fed measures about an inch and a half in length and has a dirty pale brown color with the head region darkish. The stout short reddish brown pupa is also found in the larval gallery. The life history appears to occupy a fairly long period. The insect also affects other plants like shade and avenue trees such as Casuarina, Rain tree, Peltophorum, etc., together with another form *Indarbela 4-notata* W.

Control measures.—The caterpillars may be picked up from the holes by hooked wires or a small quantity of a mixture of petrol and naphthalene can be injected into the hole by means of a syringe (fig. 234) or a small cotton wad dipped in CS_2 inserted into the hole and the latter closed; this will force out the larva which can be collected and killed. The bark of infested trees may also be sprayed with Paris green mixture; in this way, the larvæ which come out for feeding at night are poisoned and killed.

THE FRUIT SUCKING MOTHS (*Figs.* 233-4 (*c-k*) and 235 *a*, *b*.—*Othreis* (*Ophideres*) spp.—These insects are examples of adult lepidopterous creatures (moths) doing direct harm to a plant, since most moths and butterflies are only pests in their caterpillar stage. These are stout built moths having grey and orange colored wings with different markings in allied species and include chiefly the species of *Othreis*; the moth punctures the ripening fruits and sucks up the juice. Unlike as in many other moths the feeding tube of these moths is well developed and provided with sharp spines to puncture the fruit surface. Fruits which are so damaged gradually begin to rot and drop down. In bad infestations, numerous fruits

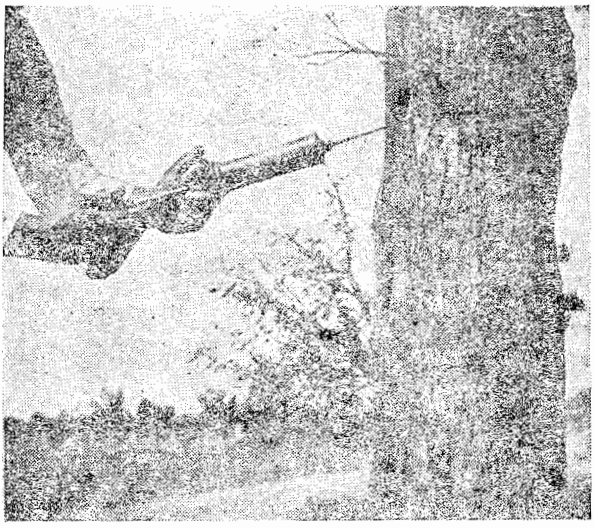


FIG. 234.—BORER SYRINGE.

[*From S.S.I.*]

are found dropped under each tree. A moth attacked fruit can be easily detected by the fine jets of juice which ooze out through fine holes when the fruit is squeezed. These moths have a wide distribution and serious damage has been occasionally reported from orange gardens in the Ceded Districts and Northern Circars. Being nocturnal in habits, these moths visit the fruit at night and are not generally seen during the day. Of the species of fruit sucking moths noted in South India, two species –*O. fullonica* and *O. materna*, –appear to be the common forms. Both the moths are large stout built insects with prominent upwardly directed palpi; the former has pale orange brown body with the fore wings dark greyish and the hind wings orange red with two black curved patches (see fig. 235); the other moth, *O. materna* has upper wings pale greenish grey with pale white markings and the lower wing with a marginal dark band mixed with white spots and with a circular dark spot at the centre of the orange brown ground colour. The other moths occasionally found in company with these are *Othreis ancilla*, C., *Calpe emarginata*, F., and *Anua coronata*, F., etc. [see fig. 235 (*a*) & (*b*)].

Life history and habits.—The fruit sucking moth is found to pass its early stages on some wild plants growing in the vicinity of the orchards. The eggs are laid on these plants and the larvæ hatching out feed on the foliage of these plants and enter the soil for pupation emerging out as moths in due course. The larvæ are stout typical semiloopers with dark brown velvety body having a curious cryptic color and structural patterns; usually there are one or more pairs of eye spots or ocelli, lateral spots of yellow or red and a dorsal

hump on the last segment. A well fed larva is a stout and cylindrical creature reaching from 2″ to 2½″ in length. This caterpillar has the habit when disturbed, of assuming a frightening posture like some sphinx caterpillars ; in this attitude, the hinder portion of the body is raised up, the head region curved round and the eye spots made conspicuous. The pupa is thick set and of a dark reddish brown colour. The pupation period generally occupies about a fortnight or twenty days. The larvæ are frequently subject to the attacks of hymenopterous parasites. In some areas these moths have been noted to attack other fruits also like mango, guava, tomato, etc. The common plant on which the larvæ of *Othereis fullonica* and *O. materna* breed in the widely distributed creeper *Tinospora cordifolia* ; other host plants noted are *Achyranthus*, *Quisqualis* and *Cocculus*.

Control measures.—The measures to check the moths consist chiefly in tackling alternate food plants in which the earlier stages are found, and preventing the moths from approaching the fruits by smokes and spraying deterrents on the trees ; crude-oil emulsion and fish-oil soap mixtures have been found effective for use in this manner. Moths are also sometimes trapped by sugaring,

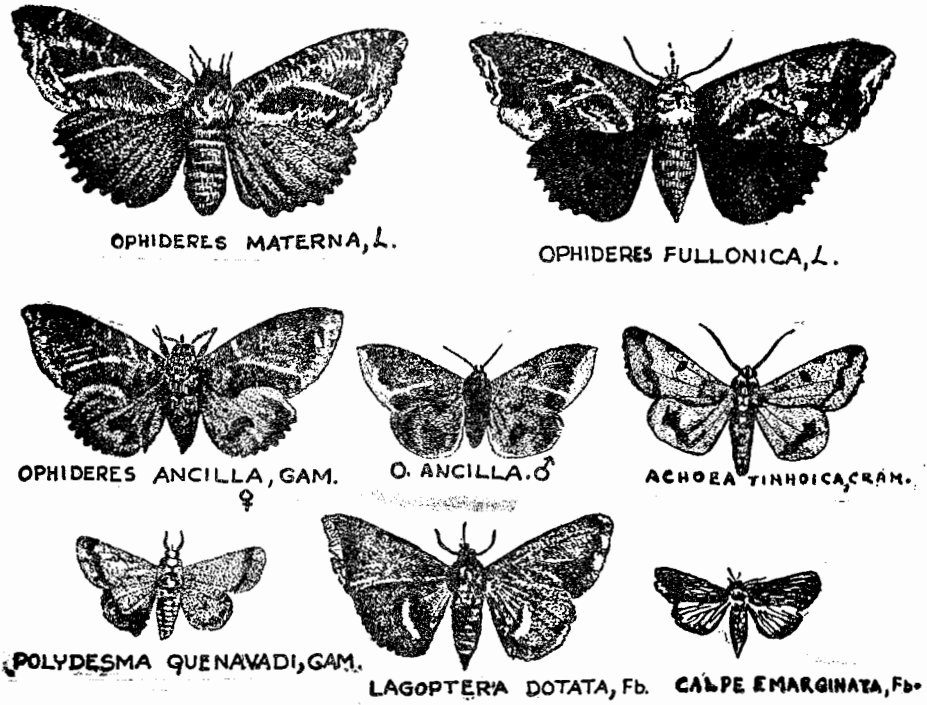


FIG. 235 (*a*).—FRUIT SUCKING MOTHS AND SOME OF THEIR ALLIES.

light traps and by poisoned baits at night. In some localities in the N. Circars, the ripening fruits are covered with cheap baskets of bamboo matting to keep away the moth.

THE CITRUS BUTTERFLY—(*Papilio demoleus*, L., fig. 233-2).—This leaf eating caterpillar is a very common insect enjoying a wide distribution. The adult insect is a beautiful black and yellow swallow tailed butterfly found flying about in most gardens during bright sunny weather. The caterpillar occasionally appears in numbers and defoliates the plants. In some of the submontane areas other species of *Papilio** are also found attacking citrus plants of different kinds.

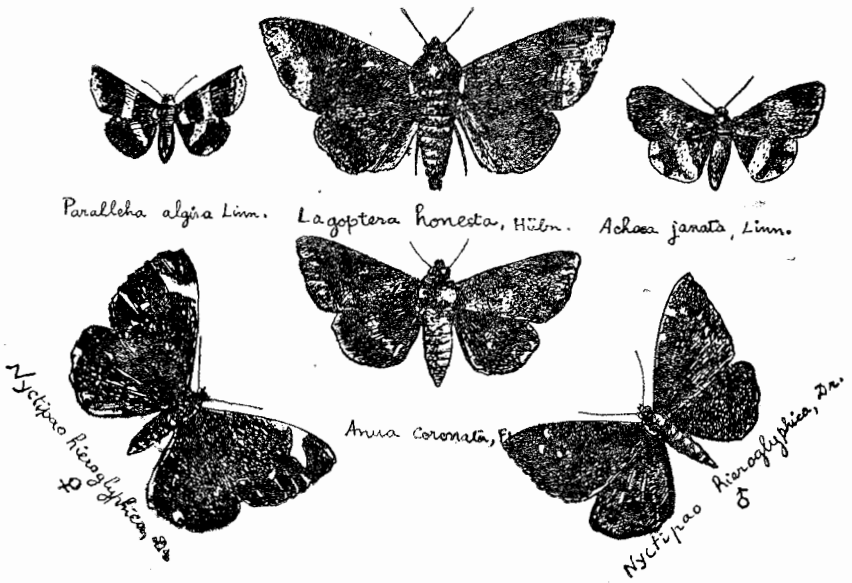


FIG. 235 (*b*).—FRUIT SUCKING MOTHS AND SOMES OF THEIR ALLIES.

Life history and habits.—The parent butterfly attaches seed like shining greenish yellow eggs singly on the tender parts of the plant, each egg hatches into a dark caterpillar which feeds on the foliage and gradually grows in size. In about a fortnight the larva changes to a deep green color, assumes a cylindrical form and measures about an inch and a half in length. The caterpillar changes into the pupa on the plant itself as a naked chrysalis attached to the plant surface by a fine silken girdle. In about ten days the butterfly emerges from the chrysalis. Usually one life cycle occupies about a month though this might vary according to seasons. The eggs and caterpillars are found frequently subject to the attacks of small wasps and often clusters of white parasitic cocoons of a wasp (*Apanteles*) are found attached to dead caterpillars on the plants.

* P. polytes and P. polymnestor.

Besides citrus varieties, the insect breeds on some other rutaceous plants also; it is found on *Murrayia* and sometimes on Bilva (*Aegle*).

Control measures.—The prompt hand picking of the eggs and caterpillars will be found very economic if done promptly. In bad infestations in large areas, spraying with an arsenic compound will be found effective. The butterflies which are day fliers and easily identified, can also be caught and killed. The presence of the insect on the alternate food plants should also be watched.

THE CITRUS LEAF MINER—(*Phyllocnistis citrella*, S., fig. 233-1).—This is a tiny greyish moth, the small pale whitish caterpillar of which mines into young citrus leaves and produces, not only mines in them but also makes them curl, fade and often dry up. This damage is often bad and persistent in young gardens. Attacked leaves show the peculiar glistening irregular mines on the leaf surface and often the tiny caterpillar inside. This pest is found all over India. All the stages of the insect are passed on the citrus leaf itself, the pupa is found inside the mine. This insect is often a serious pest and demands prompt attention. First attacked leaves may be clipped or cleared of the caterpillar by rubbing, and, as a deterrent, the other plants may be given a spray with a repellent or insecticidal mixture.

The other insects occasionally noted on citrus varieties are not very important and rarely become serious. These are mostly sucking insects like plant lice, mealy bugs, mealy wings, etc. These include (1) the citrus aphid (*Toxoptera citricidus* K., fig. 233-2), a dark brown form, colonies of which are sometimes found clustered on the tender shoots, (2) scale insects and mealy bugs of different kinds. Among scales we occasionally find the hard scales *Chrysomphalus ficus*, A., fig. 236, *Aonidiella aurantii*, M. fig. 301, *Parlatoria zizyphus*, L. the soft scales *Lecanium viride*, G., *L. hesperidum*, L., and *Saissetia coffeæ*, W., and the mealy bugs *Pseudococcus corymbatus*, G. and *Phenacoccus iceryoides*, G. Very rarely have any of these been found as serious pests. The cottony cushion scale (*Icerya purchasi*, M.) an exotic insect recently noted on the Nilgiris, has also been found on orange and other citrus varieties on the Nilgiris, (3) mealy wing (*Aleurocanthus spiniferus*, Q.), (4), the jumping plant Psyllid (*Diaphorina citri*, K.) and (5) fruit sucking plant bugs—the green pentatomid (*Vitellus orientalis*, D.), the dark pentatomid (*Cappæa taprobanensis*, D., fig. 94-2) and the greenish brown coreid (*Dasynus antennatus*, K.). All these sucking insects can be checked by preventive methods and in bad cases, by use of contact insecticides In speaking of scales and mealy bugs, attention may also be drawn here as before to the part played by different species of *ants* especially the red tree ant (*Oecophylla*) as scale and mealy bug distributors. Among minor leaf eating pests of citrus we may refer to the small leaf folding caterpillar of a tiny brown moth (*Psorosticha zizyphi*, S., fig. 237), the caterpillar of a small bluish butterfly (*Chilades laius*, C.) and a thrips (*T. nilgiriensis*, R.).

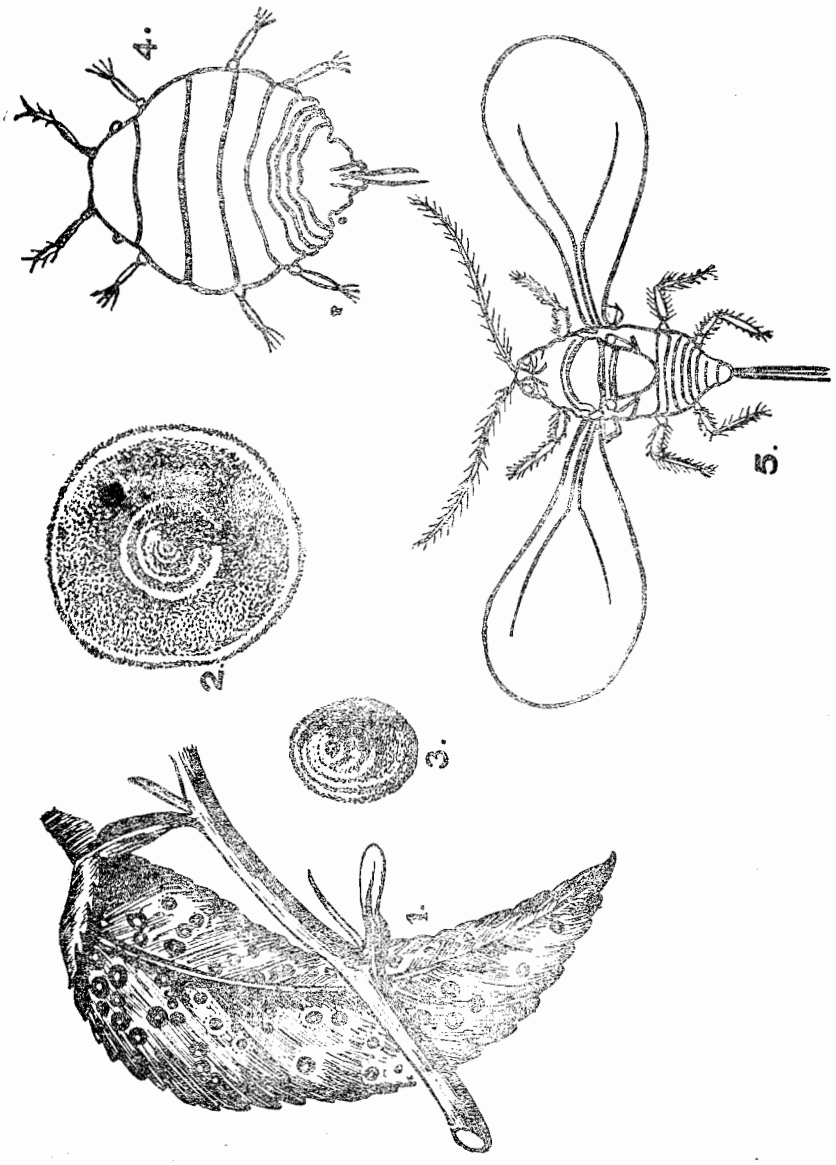


FIG. 236.—BLACK SCALE ON ORANGE.
(*Chrysomphalus ficus*, A.)

1. Scales on leaf.
2. Female scale.
3. Male scale.
4. Larva.
5. Winged male.

[*From I.M. Notes.*]

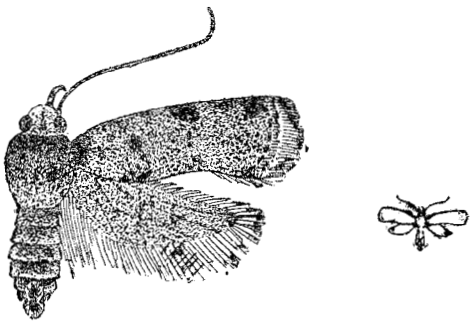


FIG. 237.—CITRUS LEAF FOLDER MOTH.
(*Psorosticha zizyphi*, S.)

[*From S.S.I.*]

GUAVA (*Psidium guava*).

The important pests of guava plant are the scales, fruit flies and the fruit moth. The scale pests include the guava mealy scale *Pulvinaria psidii*, G., (fig. 238), a specific pest of this plant and a

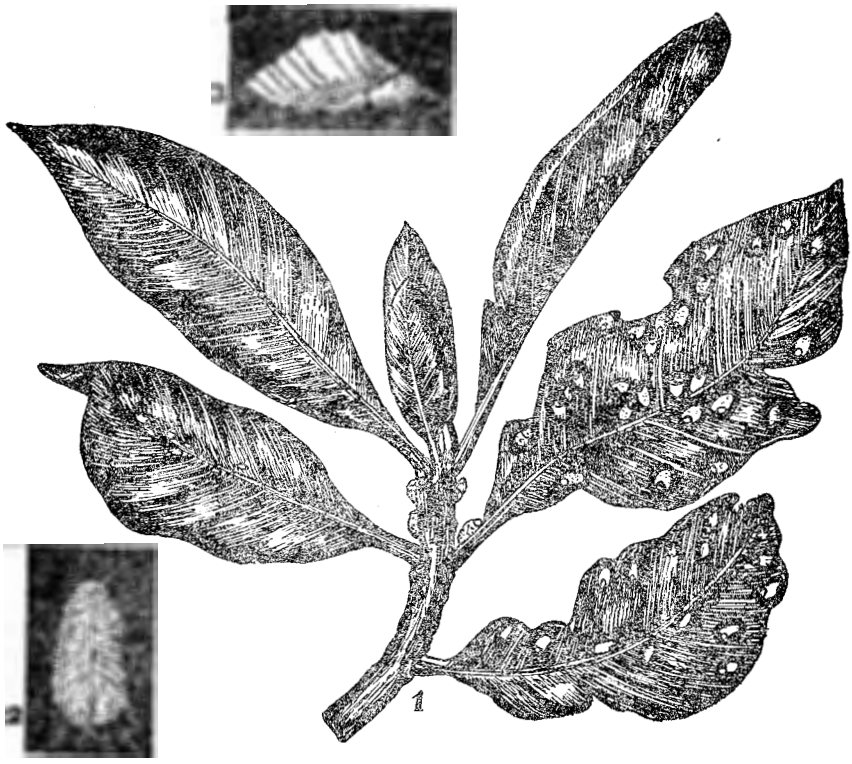


FIG. 238.—GUAVA MEALY SCALE.
(*Pulvinaria psidii*, M.)
1. Scales on foliage. 2. Female young. 3. Female mature with egg sac.

few others including the red and green bugs of coffee (*Saissetia hemispherica*, T., and *Lecanium viride*, G.), *Aspidiotus trilobitiformis*, G., *Mytilaspis pallida*, G., and the wax scale *Ceroplastes*; some of these have been referred to under mango. Prompt pruning of badly infested parts and spraying the rest with a contact poison will check these insects. The fruit flies attacking this fruit chiefly belong to a darkish brown species (*Chætodacus incisus*, W.). The fruit moth *O. fullonica* and sometimes the caterpillar of the castor capsule borer (*Dichocrocis*) also attack this fruit. A reddish brown capsid bug (*Helopeltis antoni*, S., fig. 294), which is a specific pest of tea in the hill plantations is occasionally found damaging guava shoots in Coimbatore.

Pomegranate (*Punica granatum*).

The most important and specific pest of this plant is the fruit boring blue butterfly. Others include a few leaf eating caterpillars.

Pomegranate butterfly—(*Virachola isocrates*, F.).—The caterpillar of this bluish brown butterfly bores into the ripening fruit, feeds on the seeds and allows the fruit to rot and fall down. Infested fruits generally show holes on the fruit surface often plugged by the anal segment of the caterpillar or its excretion. The insect is found everywhere and serious loss of fruits is caused in some places like Coimbatore, Northern Circars, Mysore, etc., figs. 239(1-5)-and 37.

Life history and habits.—The parent butterfly lays shining white eggs singly on the flowers or on the surface of tender fruits. The caterpillar, on hatching out of the egg, bores a hole into the fruit, and burrows into it feeding on the inner contents. The full-fed caterpillar is a dirty dark brown short and stout-built larva covered with a few short hairs and measuring about $\frac{3}{4}''$ in length. It pupates either inside a damaged fruit or on the fruit stalks on the plant. Though it has been occasionally noted to attack other fruits like guava, apple, *Sapindus*, etc., it is generally found serious only on pomegranate.

Control measures.—The method generally adopted is—covering the developing fruits with paper or muslin bags to prevent egg laying by the butterfly; this will be found advantageous especially with varieties which yield large sized fruits fetching a good price. The destruction of all badly damaged fruits and collection of the butterfly when possible will also help in the control of this pest.

The castor capsule borer (*Dichocrocis*, fig. 159–2) is occasionally found boring this fruit also.

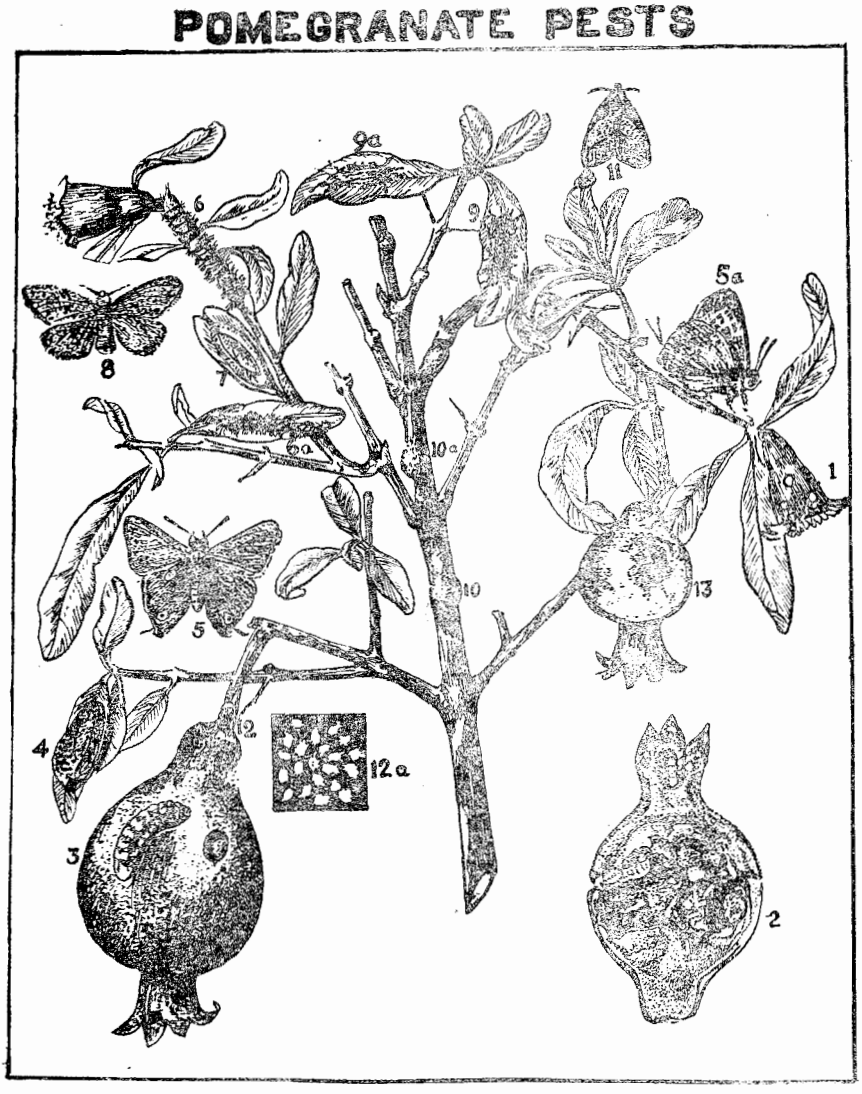


FIG. 239.—SOME POMEGRANATE INSECTS OF SOUTH INDIA.

1 to 5. The fruit borer (*Virachola*).

6 to 8. Hairy caterpillar (*Euproctis*).

9 to 11. Slug caterpillar (*Parasa*).

12 and 13. Mealy bug (*Pseudococcus*).

The leaf eating pests chiefly include some of the caterpillars affecting castor, viz., the castor slug (*Latoia lepida*, C.), the red tussock caterpillar (*Euproctis fraterna*, M.) and the semilooper (*Achœa janata*, L., fig. 159-4); the last is not so common as the first two.

The bug pests include the scales (*Aspidiotus cinerea* G.), (*Hemichionaspis thoeae*, M.) one or two mealy bugs which affect the fruit stalks and cover the fruit also (*Pseudococcus lilacinus*, C., fig. 240 being the chief species) and a mealy wing (*Siphonimus finitimus*, S.), the bluish black nymphs of which are often found in numbers on the foliage. The scales, mealy bugs and mealy wings can be easily controlled by contact spraying.

Two fruit sucking plant bugs (*Jurtina indica*, D., and *Halyomorpha picus* D.) have been noted doing some harm to this plant in some places.

The caterpillar of coffee borer (*Zeuzera*) is sometimes found as a borer in pomegranate stem in parts of Malabar (fig. 293).

A bag worm *Pteroma* has been noted in Travancore feeding on pomegranate leaves.

The longicorn beetle (*Olenecamptus bilobus*, F.) has been noted on pomegranate in parts of Salem.

Grape (*Vitis vinifera*).

The insect pests of the grape vine crop in the different parts of the province, especially in the important grape growing areas like Krishnagiri, Penukonda and Dindigul tracts include some beetles, leaf eating caterpillars, thrips, white ants and scales.

Beetles.—Of the beetle pests, the most important is the grape vine flea beetle (*Scelodonta strigicollis*, M., fig. 241) a specific pest of this crop in many parts of India. It is a small active coppery brown beetle about $\frac{1}{8}$" long belonging to the group of flea beetles; in bad attacks, numbers of the beetle feed on the tender shoots and leaves and cause substantial damage to the vines. They may be collected with nets and traps and, in bad cases, a stomach insecticide may be sprayed. DDT & BHC sprays effectively control this pest. In some cases, the vines are badly defoliated by night feeding cockchafer beetles—the chief species noted so far in South India being medium sized brown ones (*Adoretus lasiopygus*, B. fig. 242, *A. bengalensis* B. and A. *versutus*, H.). Such beetles can be trapped by lights at night and controlled by stomach sprays. Another beetle pest found on grape vine is the vine girdler (*Sthenias grisator* F., fig. 243). This insect is a medium sized stout built longicorn beetle with strongly developed mouth parts. It has the peculiar habit of ringing the vines and often killing the same; in some gardens very serious damage is caused by the beetle cutting off some of the main vines. The early stages of the insect are passed on the girdled

FIG. 240.—MEALY BUG OR POMEGRANATE FRUIT.
(*Pseudococcus lilacinus, C.*)

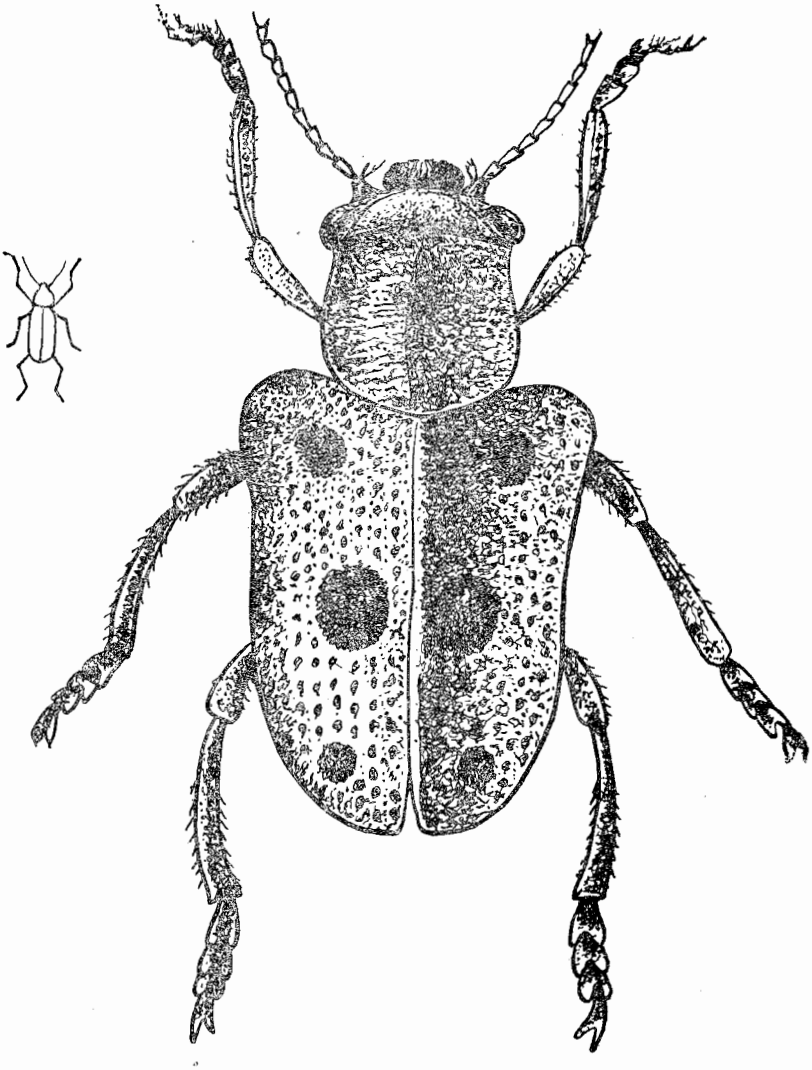


FIG. 241.—GRAPE FLEA BEETLE.
(*Scelodonta strigicollis, M.*)
Natural and magnified.

[*From S.S.I.*]

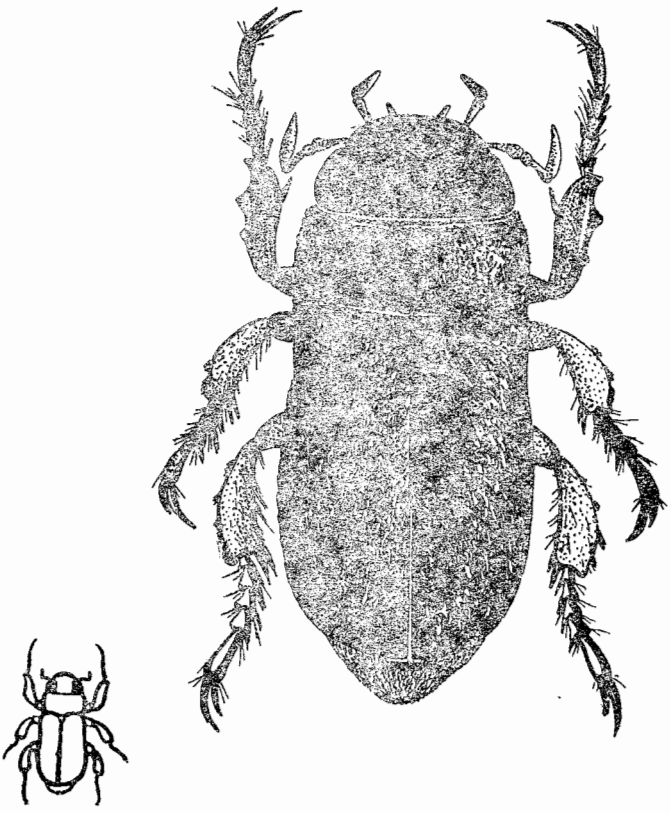


FIG. 242.—GRAPE VINE CHAFER.
(*Adoretus lasiophygus* B.)

[*From S.S.I.*]

branches in which the eggs are laid by the beetle after ringing the bark. Control measures include destruction of the ringed branches and collection of the beetles when found. This beetle also attacks *Erythrina*, mulberry and garden shrubs and creepers of different kinds. In parts of Mysore and Coimbatore, the common dark brown ground beetle (*Gonocephalum depressum*, F.) similar to one in fig. 204, is sometimes found doing damage to tender vines.

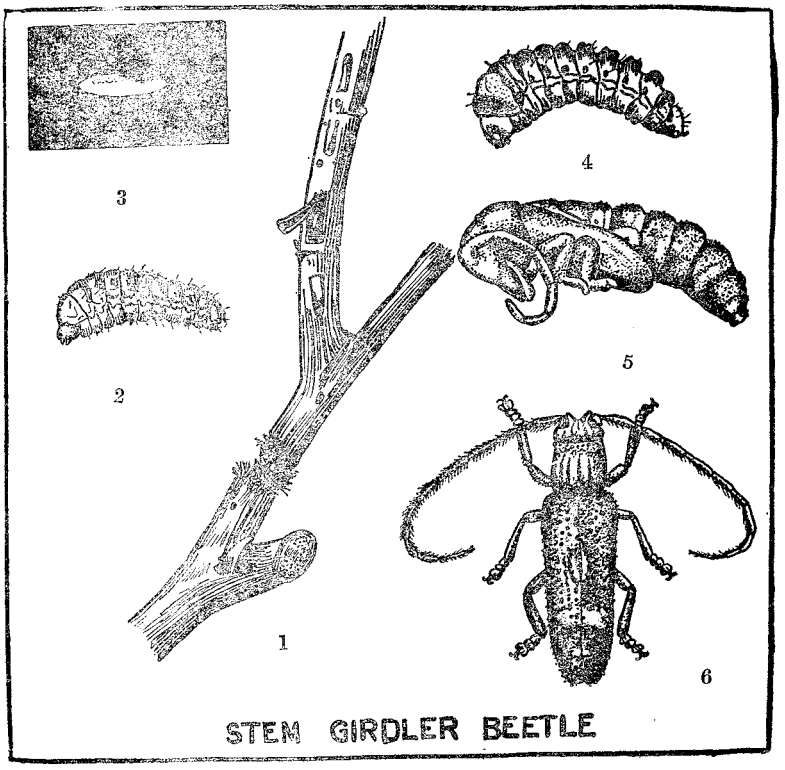


FIG. 243.—VINE GIRDLER BEETLE.
(*Sthenias grisator*, F.)
1 Attacked stem and 2 to 6 stages of insect.

Caterpillars.—These generally include the stout sphingid (*Hippotion celerio*, L.) the larva of a stout red and brown hawk moth, a leaf rolling pale green caterpillar (*Sylepta lunalis*, G.) the adult of which is a brownish moth with the wings having wavy patterns, and a very small leaf mining caterpillar (*Phyllocnistis toparcha*, L.) the larva of a very small grey brown moth. None of these insects generally assumes serious proportions. They can be easily hand-picked or controlled by stomach sprays when necessary. In Mysore the caterpillar of a plume moth (*Oxyptilus regulus*, M.) has been found boring into the berries and causing some injury.

Grape Thrips.—The tender foliage of grape is in many places affected by thrips which lacerate the tissue, suck up the juice and make the leaves fade and dry, fig. 244. The grape *thrips* (*Rhipiphorothrips cruentatus*, H.) is specific to grape though found on other plants like roses, country almond, etc. (fig. 97–2). The pest can be easily checked by tobacco dusting or spraying.

FIG. 244.—DAMAGE BY GRAPE THRIPS.
(*Rhipiphorothrips.*)

Termites (*Odontotermes* sp.).—These cause damage to newly planted setts of grape vine in notoriously white ant infested areas; whole vines are often hollowed out and the tender shoots killed. Dipping of setts in crude oil emulsion DDT & BHC or tar water and mixing crude oil emulsion with the irrigation water will give relief.

Scales.—Occasionally the vines are covered by small pale grey hard scales (like *Aspidiotus lataniæ*, S., and *A. cydoniæ*, C., fig. 245) and soft scales (like *Lecanium longulum*, D., and *Pulvinaria maxima*, G., fig. 324). These can be checked by contact washes.

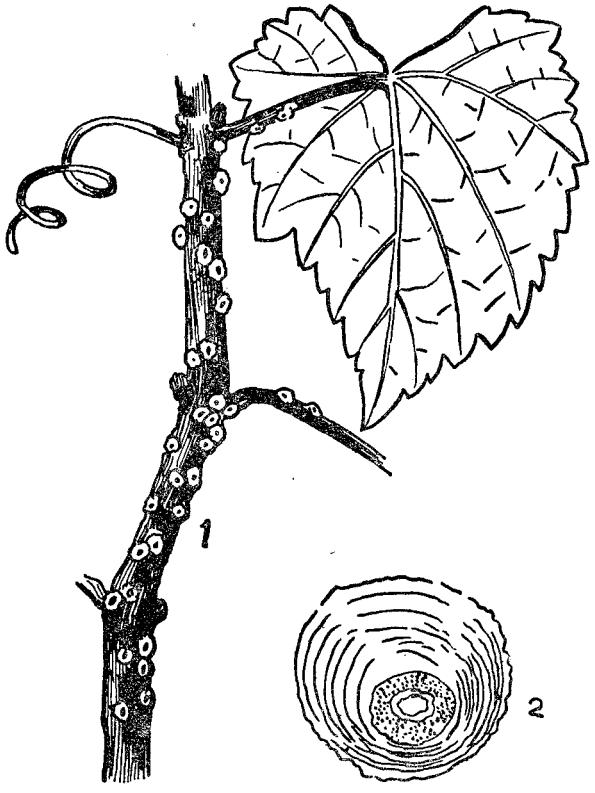


FIG. 245.—SCALES ON GRAPE VINE.
(*Aspidiotus cydoniae*, C.)
1 Infested vine. 2 Scale enlarged.

BANANA (MUSA SPP.).

The various varieties of the banana crop grown all over the province have not so far been found to suffer from any serious damage though some insects are generally found feeding on the plant. These chiefly include leaf eating caterpillars like the castor slug (*Latoia lepida*, C.), the tobacco caterpillar (*Prodenia litura*, F.) and the black

hairy caterpillar noted on castor (*Pericallia ricini*, **F., fig. 159-1,** 3 & 7). The author has recently noted a nettle grub caterpillar (*Miresa decadens*, W.) feeding on banana foliage and causing some damage in parts of Malabar. It is quite different from the castor slug though it may be mistaken for the latter ; the moth is grey brown with a golden velvety bloom all over the body surface. A small bag worm—psychid (*Kophene cuprea*, M.) has been noted feeding on the foliage in parts of the Coromandel Coast. These leaf pests are easily checked when in numbers by mechanical methods alone. The notorious banana borer weevil (*Cosmopolites sordidus*, G., fig. 246) which has a wide distribution all over the tropics has been noted in Malabar, Tinnevelly and Ganjam till now ; but no serious damage has been noticed so far. It is a difficult pest to check and only preventive methods are feasible. Infested suckers should not be used for propagation.

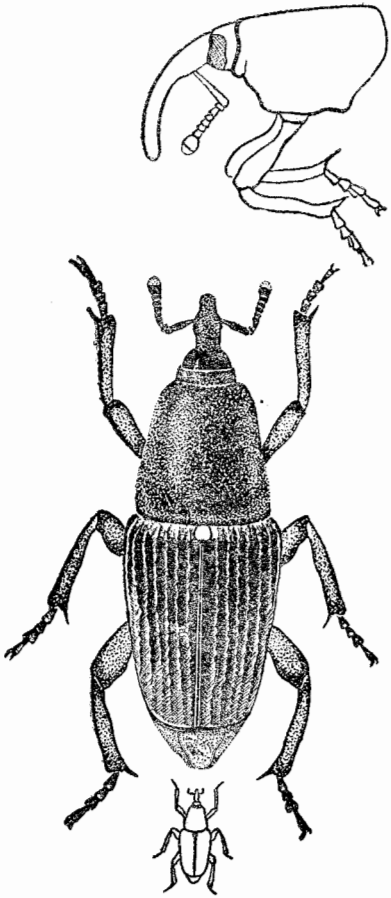


FIG. 246.—BANANA STEM WEEVIL.

Minor pests of banana include a small transparent whitish lace-wing bug (*Stephanitis typicus*, D., fig. 247), one or two species of spittle bugs (chiefly the red and blue *Phymatostetha deschampes*, L.), a few scales (*Aspidiotus destructor*, S., fig. 269, *A. cyanophylli*, S., and *Lecanium discrepans*, G., fig. 248) a capsid bug *Prodromus subviridis*, D. and a species of thrips often becoming sporadic in Malabar (*Heliothrips kadaliphila*, R.). Sometimes the scales are found on the fruits also. Colonies of plant lice (chiefly the species *Pentalonia nigronervosa*, C.) are sometimes found on tender banana leaves. No fruit fly has till now been noted on banana in this province, though such a fly is recorded from Burma.

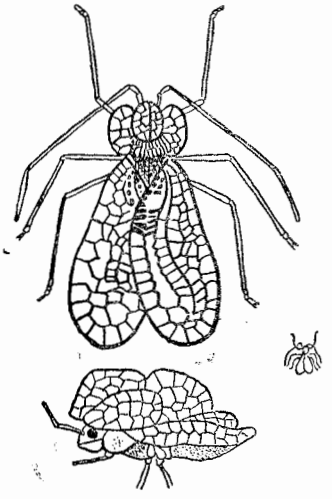


FIG. 247.—BANANA LACE-WING BUG.
(*Stephanitis typicus*, D.)
[After Distant.]

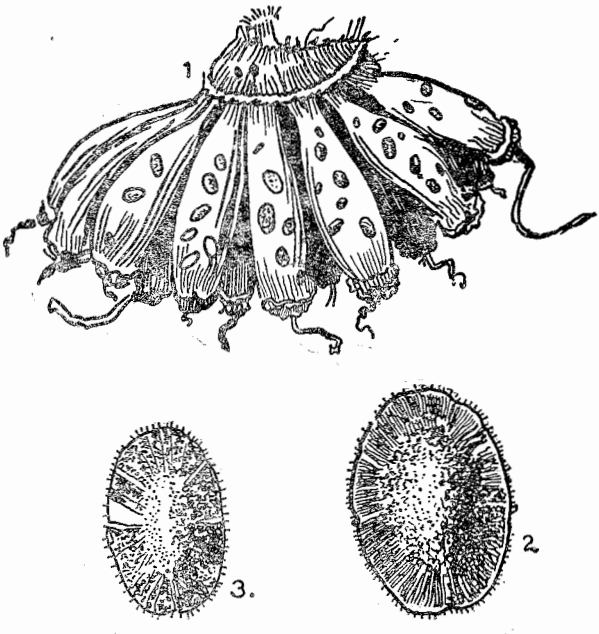


FIG. 248.—SOFT SCALE ON BANANA.
(*Lecanium discrepans*, Gr.)
1 Scale on fruits.
2 and 3 Scales in different stages.

MELONS.

The chief insects on melons of different kinds are those found on Cucurbitaceæ, especially pumpkins, cucumbers, and gourds (*see* page 250). Among these the fruit flies are the most important.

FIG.

The important pests of cultivated fig are—(1) a stem boring longicorn beetle (*Olenecamptus bilobus*, F., fig. 249), a slender pale whitish insect with long antennæ ; the whitish grub of this creature

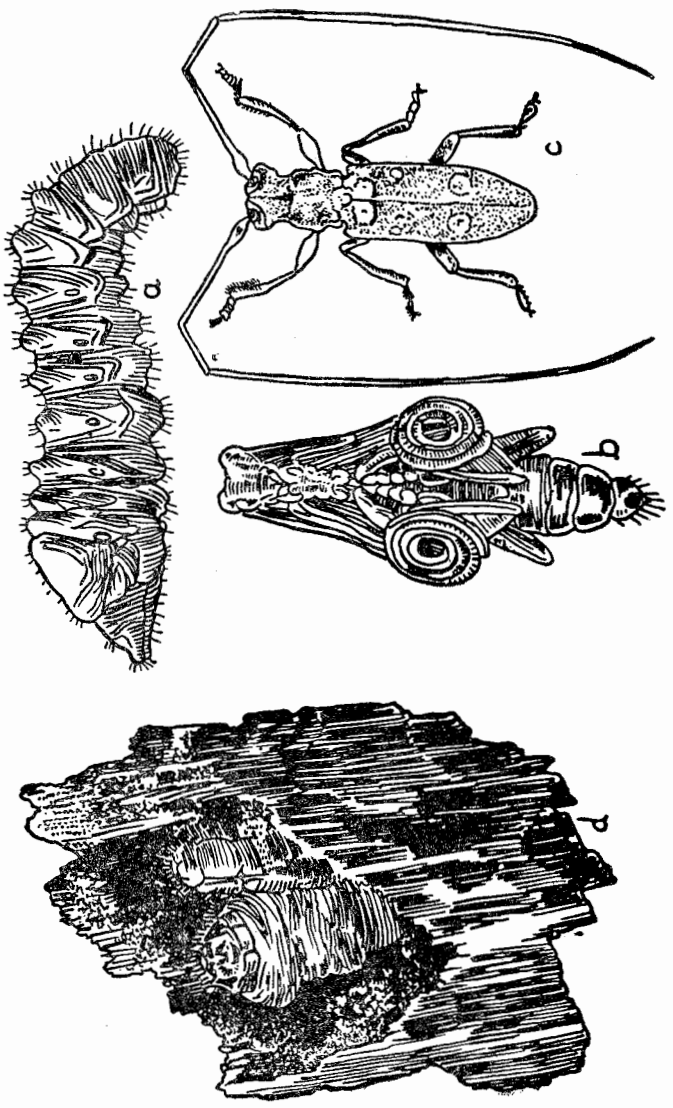


FIG. 249.—FIG STEM BORER BEETLE.

(*Olenecamptus bilobus*, F.)

a, *b* & *c* Stages of grub, pupa and adult. *d* Borer in stem.

[*From I.E's Rpt.* 1920.]

bores into the stem like the stem borers on mango citrus, etc. The same remedies have to be adopted as against the borers on mango. (2) Leaf-eating caterpillars of different kinds including (*a*) a small whitish wild silkworm (*Ocinara varians*, W.) the caterpillar of a pale whitish moth, fig. 394, (*b*) the hairy caterpillars (*Perina nuda*, F., and *Hypsa ficus*, F., fig. 250) and (*c*) other leaf eating forms (*Phycodes radiata*, O., fig. 251, *Margaronia stolalis*, G., *Glyphodes phyloalis*, W. and *Selepa celtis*, M.). These can be checked by mechanical methods or stomach sprays, (3) some scale insects and mealy bugs (*Saissetia oleæ*, B., *Aspidiotus cydoniæ*, C., *Pseudococcus lilacinus*, C., *Lecanium ramakrishnæ*, G., fig. 252) and (*Leucaspis riccae*, P) are occasionally found on the shoots and stems, but very rarely in a serious condition, (4) a dark giant thrips (*Gigantothrips elegans*, Z.) is usually found on the tender foliage causing the leaves to curl and fade. The infested leaves can be clipped and an application of tobacco dust given. In some species of fig (especially *Ficus glomerata*) the leaves are often badly galled by some psyllid bugs—chief being *Pauropsylla depressa*, C and *Dinopsylla grandis*, C. Some of these *psyllid* galls are very characteristic plant malformations (fig. 34). The grasshopper (*Poecilocerus pictus*, F) has been noted as a minor pest on fig in Ceded districts. The Spittle bug (*Cosmocarta niteara*, D) is found occasionally in South Canara.

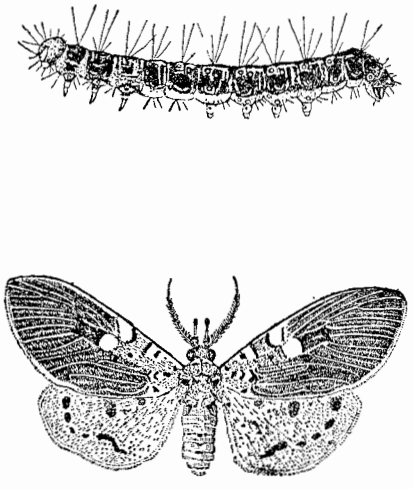


FIG. 250.—FIG HAIRY CATERPILLAR AND MOTH. (*Hypsa ficus*, F.) [*From S.S.I.*]

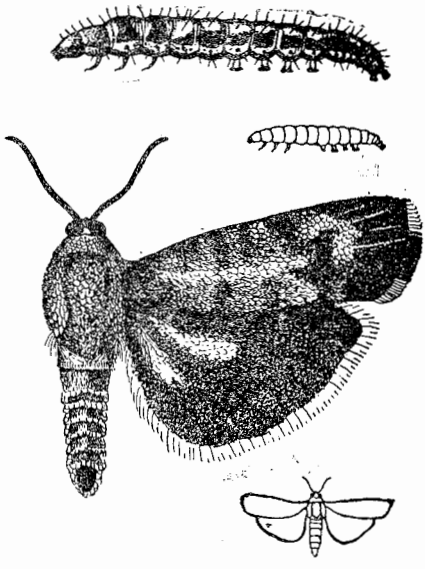


FIG. 251.—FIG LEAF ROLLER. (*Phycodes radiata*, O.) [*From S.S.I.*]

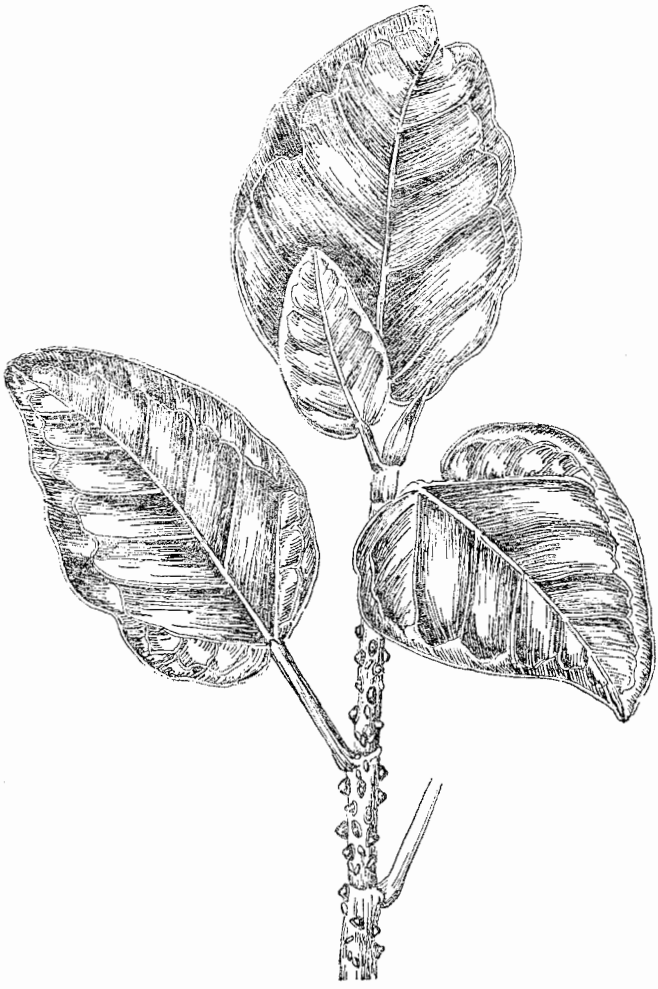


FIG. 252.—SCALES ON FIG SHOOTS.
(*Lecanium ramakrishnæ*, G.)

JAK AND BREAD FRUIT TREES.*

Of these two trees, it is the common jak (*A. integrifolia*) which is subject to important pests. These include—

(1) *Shoot borer*—the larva of a whitish brown moth with greyish patterns on the wings *Margaronia cæsalis*, W., fig. 253. This reddish brown caterpillar bores into the tender shoots and developing fruits and causes substantial damage in many places such as Malabar, Godavari, etc.

* Artocarpus spp.

(2) *Jak bud weevil* (*Ochyromera artocarpi*, M.).—This is a small grey brown weevil, the small whitish grubs of which bore into the tender buds and fruits, fig. 26. This insect is found all along the Western Ghats and parts of Mysore. Only preventive measures such as the destruction of all infested and fallen buds and fruits, and collection of weevils when found are possible.

(3) *Scales and mealy bugs.*—A wax scale (*Ceroplastes rubens*, M., fig. 254) sometimes covers the leaves; the tender shoots and buds of both jak and bread fruit tree are often covered by white masses of mealy bugs (chiefly *Icerya ægyptiaca*, D. and *Pseudococcus*

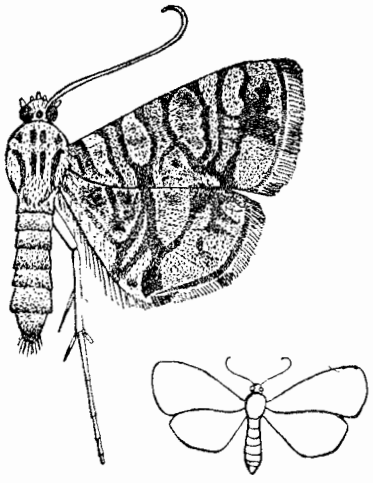


FIG. 253.—JAK SHOOT BORER MOTH.
(*Margaronia cæsalis*, W.)
[*From S.S.I.*]

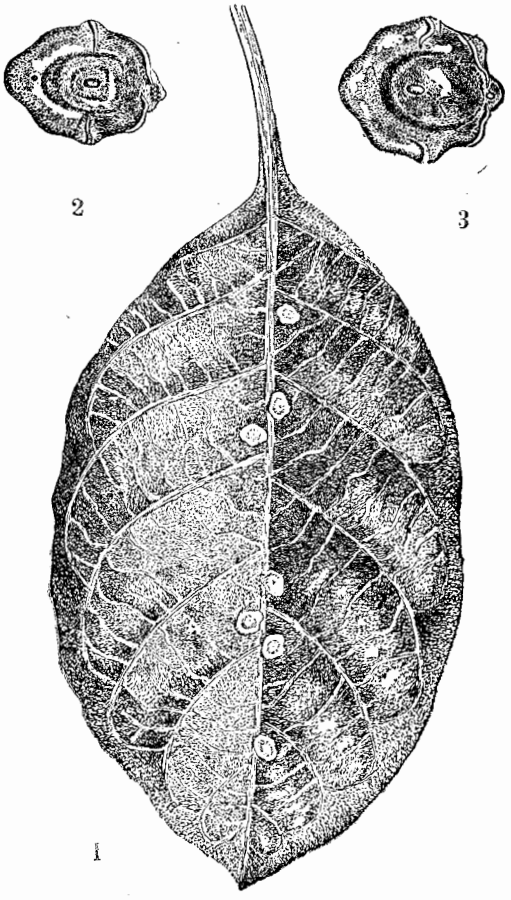


FIG. 254.—WAX SCALE ON JAK.
(*Ceroplastes rubens*, M.)
2 & 3 Female scales enlarged.

corymbatus, G.) attended by swarms of ants. In parts of Mysore and Coorg, a small dark scale (*Aspidiotus triglandulosus*, G.) covers the foliage and does some harm. In all bad cases, pruning and spraying with contact insecticides may be adopted.

(4) *Jak spittle bugs.*—One or two species of these insects occasionally appear in swarms on the tender shoots and foliage and allow the leaves to curl up; the common forms noted are small creatures (species of *Ptyelus* and *Clovia*, fig. 255) but in Coorg and parts of South Mysore a fairly large sized spittle bug reddish in colour (*Cosmoscarta relata*, D., fig. 256) has been noted on jak in swarms covering whole branches with its frothy secretion.

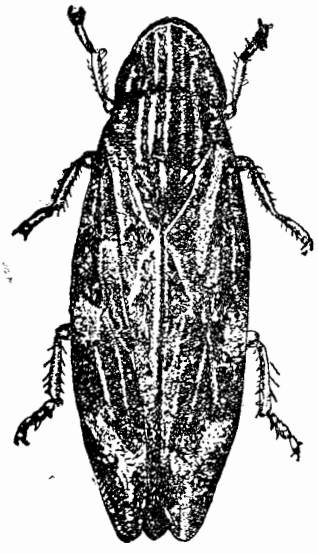


FIG. 255.—SPITTLE INSECT ON JAK.
(*Clovia lineaticollis*, M.)

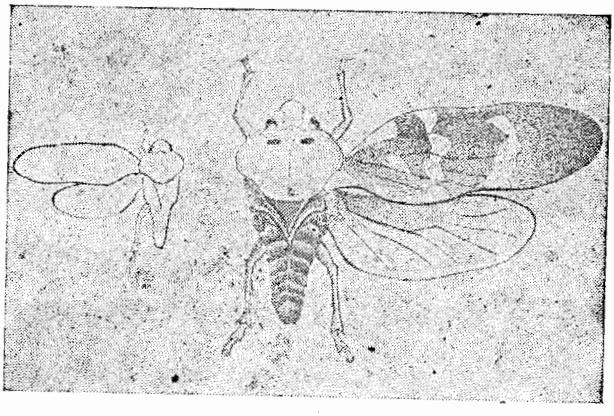


FIG. 256.—LARGE SPITTLE BUG OF JAK.
(*Cosmoscarta relata*, D.)
[*From S.S.I.*]

(5) *Jak aphid* (*Greenidea artocarpi*, *W.*).—This is a plant louse specific to jak attacking the tender parts; it is a large form with long hairy cornicles. A shining black longicorn beetle (*Glenea belli*, G.) has been recorded as a stem borer of Jak in South India by Beeson.

Sapota (*Achras sapota*).

Very rarely have insects caused any serious damage to this crop so far, though it is possible that the mangohopper and some scales and mealy bugs are potential pests. Now and then some leaf

eating caterpillars, both smooth and hairy, are also seen on the plants but not as pests. A boring caterpillar *Nephopteryx ugraphella*, R., has been recently noted to do some damage to the buds and tender shoots in Coimbatore. Mealy bugs (*Pseudococcus* spp.) also occur as minor pests.

Woodapple.*

The only noteworthy pest so far noted causing appreciable damage to this tree is a slender brown caterpillar—the woodapple borer (*Euzophera plumbei fasciella*, H.) attacking the fruits. The castor slug (*Latoia lepida*, C.) which occasionally attacks the foliage and another small moth caterpillar (*Argyroploce illepida* B.), are minor pests.

Jujub.†

Both the wild and cultivated varieties of this fruit tree are subject to the attacks of a few insect pests. Of these the important ones noted are—(1) The fruit boring caterpillar (*Meridarchis scyrodes*, M.) the reddish larva of a small dark brown moth; the wild fruits are particularly subject to this pest and a good percentage of these are bored.

(2) The Ber fruit fly (*Carpomyia vesuviana*, B., *fig.* 258).—A small black spotted fly with banded wings; this is a specific pest of this fruit and is, in fact, the most important pest of both the wild and cultivated varieties. The usual remedies against fruit

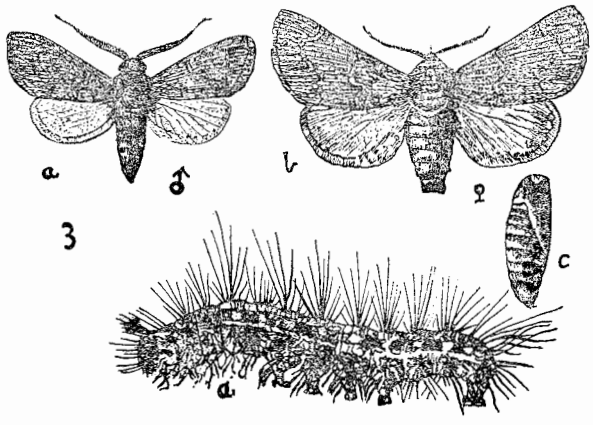


FIG. 257.—ZIZYPHUS HAIRY CATERPILLAR.
(*Thiacidas postica*, W.)
(Caterpillar, pupa, male and female.)
[*From I.M. Notes*]

* Feronia elephantum.
† Zizyphus jujuba.

flies can be adopted for both the boring caterpillar and the fly. Raking up the soil round the trees is reported to destroy the pupal stages of the latter. The fly is generally parasitised by braconid wasps.

Those of minor importance include the following :—A grey brown hairy caterpillar (*Thiacidas postica*, W., fig. 257) is often found in swarms on the foliage. The small fleshy green larva of a blue butterfly (*Tarucus theophrastus*, F.) also breeds on the leaves but is never serious. The insects attacking the shoots and foliage are a few beetles including a large yellowish grey weevil (*Myllocerus transmarinus*, *H.*) and a small spiny leaf beetle (*Platypria andrewesi*, W.) ; scale insects (*Ceroplastodes cajani*, M., and *Pulvinaria maxima* G.) small cowbugs lace wing bugs on the tender foliage and a tube constructing spittle bug (*Machœrota*). Of these, the scales sometimes cause appreciable damage.

Custard Apple.*

The shoots and fruits of this plant have been found subject to the following insect pests. (1) mealy bug (chiefly *Ferrisiana virgata*, C., fig. 218) ; these sometimes completely cover the shoots and fruits, (2) fruit boring moth caterpillar (*Heterographis bengalella*, H.), (3) fruit flies (chiefly *Chœtodacus zonatus* S.). The caterpillar of a small moth (*Pyroderces falcatella*, St.,) is occasionally found on custard apple.

Jambu.†

Very few insects affect this tree seriously, though leaf weevils, caterpillars, mealy wings, jumping bugs, thrips, etc., are occasionally found on it. Fruit flies (chiefly *Bactrocera correctus*, B.) attack the fruit. A small weevil (*Balaninus C-album*) is found on the fruits. The greenish caterpillar of a purple winged moth (*Carea subtilis*, W., fig. 259) attacking the leaves is a specific insect of this tree ; this caterpillar has the anterior part of the body conspicuously swollen. The mealy wings (*Dialeurodes eugeniæ*, M.) and the Psyllid jumping bug (*Trioza jambolanæ*, C.) hardly cause any serious harm though they produce malformations of the shoots and foliage.

Other insects occasionally noted on this tree include a long tailed species of thrips (*Leeuwenia karnyi*, R.) the caterpillar of the moth *Bombotelia delatrix* G., and the leaf rolling caterpillar of the moth *Argyroploce aprobola* noted on mango ; this last occasionally causes some appreciable harm.

Tamarind (*Tamarindus indicus.*)

Scale insects and mealy bugs of different kinds often cause some damage to this tree—especially to the tender shoots and fruits which are literally covered with these insects during certain

* Anona squamosa.
† Eugenia jambolana.

seasons. These include both hard scales (*Aonidiella orientalis*, N., *A. tamarindi*, G., and *Saissetia oleæ* B., fig. 260) and mealy bugs (*Pseudococcus lilacinus*, C., and *P. corymbatus*, G.). The curious crab caterpillar found on redgram—*Stauropus alternus*, W., fig. 137, is sometimes noted on tamarind foliage but only as a minor pest. Bag worms (chiefly *Chaliodes vitrea*, H., and *Pteroma plagiophelps*, H.) are occasionally found damaging the foliage also. Sometimes the pomegranate butterfly (*Virachola isocrates*, F., fig. 239) is also found breeding inside the fruit. Inside ripening fruits a stout legged dirty brown bruchid beetle (*Pachymerus gonagra*, F., fig. 340) is also found, though this insect is generally seen only on stored tamarind.

Cashew.*

Insects visiting this tree have been so far found to do harm only to the different parts other than fruits and these are mostly sap sucking forms. These include (1) the red banded thrips (*Selenothrips rubrocinctus*, G., fig. 97–3), which is the notorious Cacao thrips of Ceylon and other tropical regions; in parts of North Malabar it is occasionally found doing damage to tender leaves and flowers by sucking the sap and causing them to fade, another species (*Rhynchothrips raoensis*, R.), is noted with this pest in parts of Malabar, (2) the active reddish brown plant bug (*Helopeltis antoni*, S., fig. 294) which is a well known pest of tea, and which attacks the tender shoots, and (3) two scale insects the wax scale (*Ceroplastes floridensis*, C.) and the soft scale (*Lecanium latioperculum*, G.,) the former is sometimes bad. Of other pests, the leaf eating caterpillar of the wild silk moth (*Cricula trifenestrata*, H. fig. 261)—a stout reddish brown hairy caterpillar, is occasionally found in swarms on this tree and on *Caryea arborea* in different areas along the West Coast; the golden yellow hairy and spiny silken cocoons of these caterpillars are sometimes found in masses on the tree branches. The leaf mining caterpillar of a small moth (*Acrocercops syngramma*, G.) often causes pale white leaf blisters making the leaves curl up. Occasionally pretty little long snouted dark weevils (chiefly *Apion amplum*, F.) are found nibbling the shoots, fig. 262. The longicorn beetle stem borers *Plocaederus ferrugineus*, L. and *Prionoma atratum*, G., have been noted on this tree in parts of Cochin, Travancore and Tanjore.

Miscellaneous Fruit Trees.

Country almond (*Terminalia catappa*).—This tree is not subject to any serious pests. Among those noted on it are (1) the leaf twisting reddish brown weevil (*Apoderus tranquebaricus*, F., fig. 226); the eggs and developing stages of this insect are found in curious knots made of the tender leaves of this tree, which are easily noted on infested trees; the insect is also occasionally found on mango, (2) the grape thrips (*Rhipiphorothrips cruentatus*, H.) is found on the tender parts, and (3) scale insects (chiefly *Saissetia nigra*, N. and S., *hemispherica* T., figs. 308 and 290.)

* Anacardium occidentale.

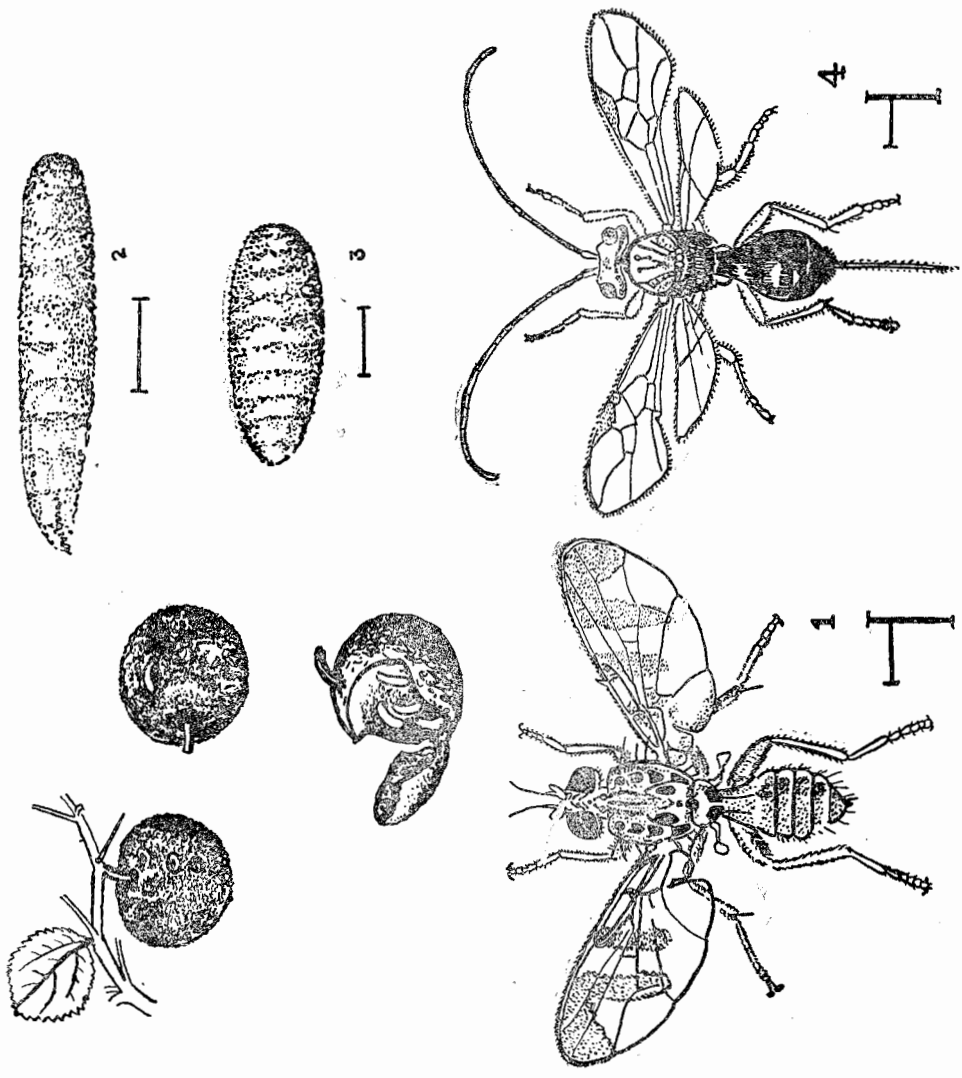


FIG. 258.—ZIZYPHUS FRUIT-FLY AND PARASITE.
(*Carpomyia vesuviana*, A.C.)
1 to 3 Fly and stages. 4 Parasite—Braconid wasp.

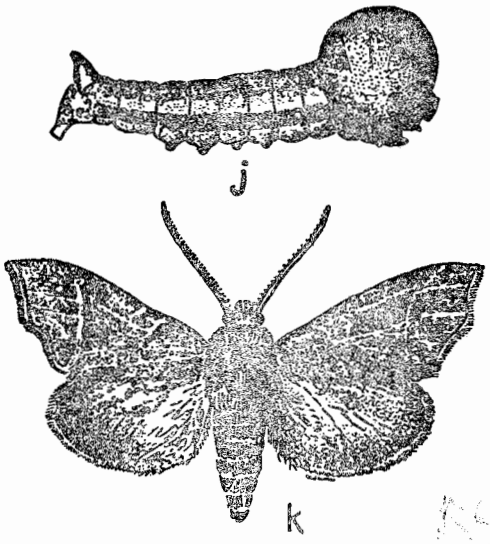


FIG. 259.—EUGENIA CATERPILLAR AND MOTH.
(*Carea subtilis*, H.)

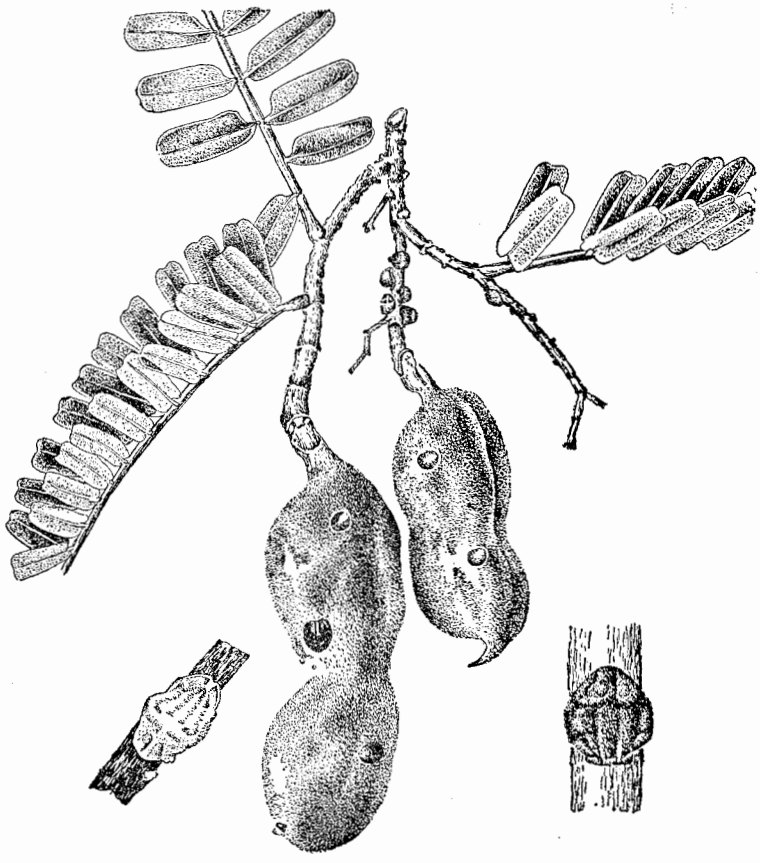


FIG. 260.—SCALE ON TAMARIND FRUITS AND TWIGS.
(*Saisselia oleae*, B.)

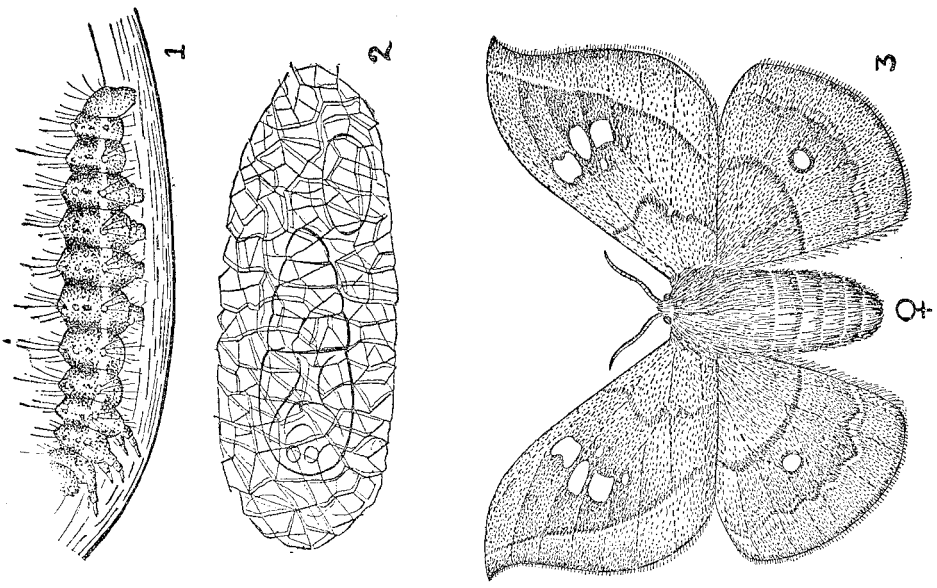


FIG. 261.—WILD SILKWORM FOUND ON CASHEW.
(*Cricula trifenestrata*, H.)
1. Caterpillar. 2. Cocoon. 3. Moth.
[*From S.S.I.*]

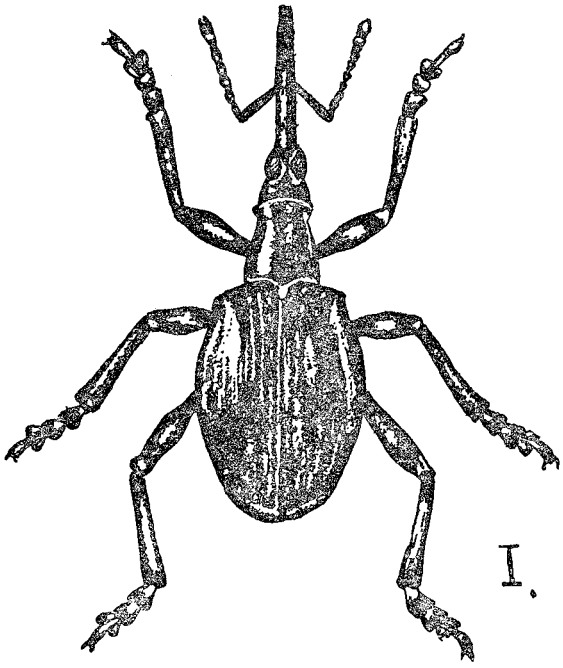


FIG. 262.—LEAF WEEVIL ON CASHEW.
(*Apion amplum*, F.)

NELLI (*Phyllanthus emblica*).—The insects found on this tree include (1) mealy bugs of different kinds (*Pseudococcus* spp.) covering the tender parts, (2) a bluish metallic green plant bug (*Scutellera nobilis*, F.) which sucks the fruit—noted only in parts of the Northern Circars, and (3) a small leaf rolling moth caterpillar of very minor importance (*Gracillaria acidula*, M.). An aphid (*Setaphis bougainvilliæ*, T.) and a mealy wing have also been noted on the garden species of phyllanthus in different localities.

A specific pest of this tree is a gall forming caterpillar of Therevid moth (*Betousa stylophora*, S.) common in the ceded districts and northern Circars.

PINE APPLE (*Ananas sativus*).—No insect pests of any importance have been noted on this crop in Southern India ; but the pine apple mealy bug (*Pseudococcus bromiliæ*, B.) was noted on one or two occasions by the author in Malabar.

MULBERRY (*Morus* sp.).—The only important pest of this crop, which is generally grown for silkworms in parts of Mysore and Kollegal, is the stem girdling beetle. (*Sthenias grisator*, F., fig. 243) already noted under grape vine. The mealy bug pest (*Tukra*) of Northern India has not been noted till now.

BOEL OR BILWA (*Aegle marmelos*).—In Southern India this plant is cultivated more for its foliage for use in worship than for its fruits. The leaves and shoots are very often badly infested by the green coffee scale (*Lecanium viride*, G.). In some places a small black shining flea beetle (*Clitea indica*, J.) and its yellowish white grubs seriously defoliate this tree, fig. 89-2. The citrus butterfly (*Papilio demoleus*, F.) is also found breeding on this plant but does not affect it seriously.

PAPAYA (*Carica papaya*).—No pests have been noted on this plant till now.

APPLES, PEARS, PEACHES, PLUMS, ETC.

These fruit plants of the temperate regions are grown to some extent only on the hills and on the Mysore plateau in Southern India. The insects noted on all these are more or less similar. The chief of these noted so far include plant lice, scales and fruit flies. The plant lice include two forms—one, the notorious woolly blight (*Schizoneura lanigera*, H., fig. 263) which is apparently an introduced pest, and which is often serious on apples on the hills, and another (*Dilachnus krishni*, G.). Hard scales especially (*Aspidiotus cydoniae* C., fig. 245) are sometimes found on introduced stalks of apples, peaches, etc. Leaf weevils (generally *Myllocerus subfaciatus*, G, and *M. maculosus*, D.) are found occasionally, but are of minor importance. Of some importance are the fruits flies (*Chaetodacus*, spp.) which attack peaches, plums, perisimmon, etc. The two notorious exotic pests cottony cushion scale (*Icerya purchasi*, M) and

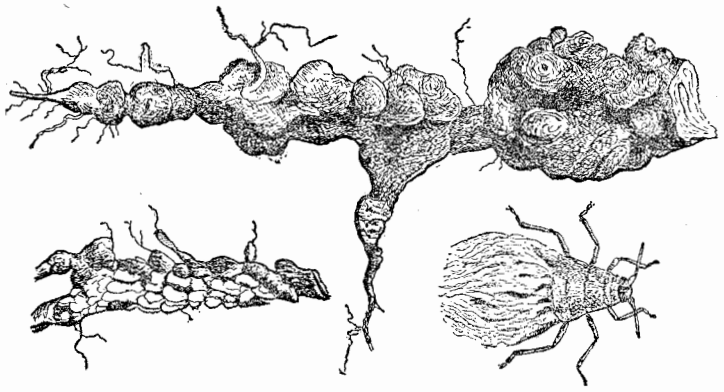


FIG. 263.—WOOLY BLIGHT OF APPLE.
(*Schizoneura lanigera*, H.)

[*After Mariatt.*]

the San Jose Scale (*Quadraspidiotus perniciosus*, C.,) have also been recently noted on apples, peaches, etc., in parts of Mysore and Nilgiris (figs. 73 and 74). The woolly blight, the fruit flies and the scale pests should receive prompt attention in the case of these exotic fruit plants and in importing stocks from outside the country, care should be taken to see that only pest-free material is brought in. The parasite *Aphelinus mali* is being tried as a natural enemy in some places with very encouraging results.

PESTS OF PALMS.

The important palms of economic importance in Southern India are the coconut, the palmyra, the areca and the date palm; of these, the two former are chiefly subject to the attacks of some important insects.

Coconut.

The most important of the insect pests of coconut are the rhinoceros beetle (*Oryctes rhinoceros*, L.), the palm weevil (*Rhynchophorus ferrugineus*, F.), and the black headed caterpillar (*Nephantis serinopa*, M.). All others are of minor importance though occasionally some of them appear as sporadic local pests.

The Rhinoceros Beetle (*Oryctes rhinoceros*, L., fig. 264, a, b, c.) —This is a stout built black insect belonging to the group popularly known as cock-chafer beetles. It is elongate and cylindrical and measures about an inch and a half to two inches. The body above is smooth and shining black, while the ventral side is brownish and hairy; it has well-developed wings and can fly long distances. On the face the beetle has a pointed horn which is longer in the male; the insect is therefore called the rhinoceros beetle. It has a very wide distribution, being found all over peninsular India especially along the coastal areas, Ceylon and the Indo-Malayan regions. The beetle causes harm by boring into the unopened tender fronds, biting the fibrous portions, chewing the juice from the fibrous material and throwing it out as a dry fibrous mass; this mass is

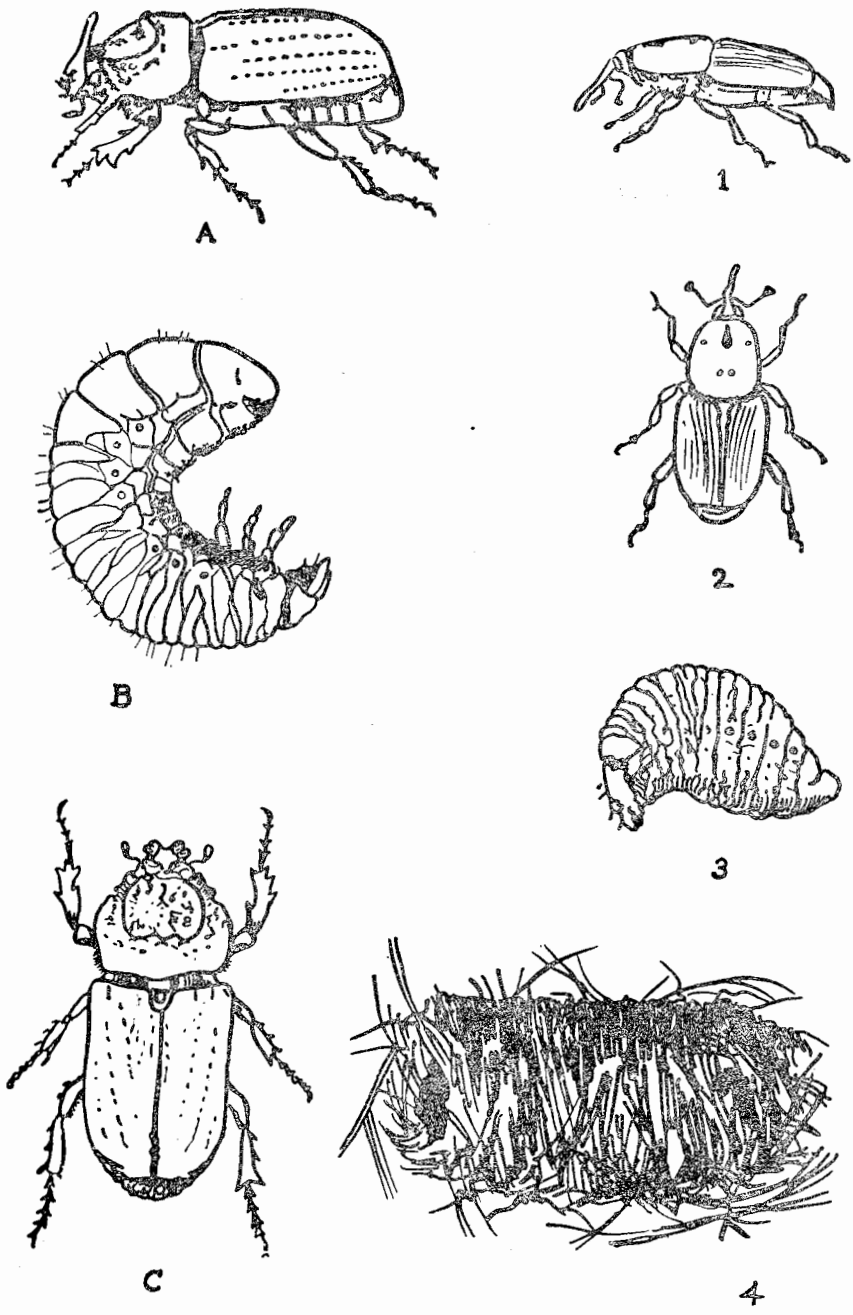


FIG. 264.—PALM BEETLES AND THEIR STAGES.

A, B & C.—The Rhinoceros beetle (*Oryctes rhinoceros*, L.) and grub.
1, 2, 3 & 4.—The Red palm weevil (*Rhynchophorus ferrugineus* F.), grub and cocoon.

commonly seen in the burrow made by the beetle. The injury thus caused to the young fronds is seen clearly as a series of holes on the

fronds when they open out; this is the characteristic outward indication of an infested tree. When the growing point is cut, as it sometime happens, the tree suffers seriously and in some cases, dies off. The damage caused by the beetle is more serious in the case of young trees.

Life history and habits.—The early stages of the beetle are genarally passed in manure pits and decomposing vegetable matter chiefly dead palm trunks; they are not usually found in healthy palm trees. The oval white seed-like eggs are laid singly in decomposing cattle or other manure, and these hatch into active small wriggling pale yellowish white grubs in about 8 to 20 days with great variations. The just hatched grub is about $\frac{1}{4}''$ long and has the three pairs of thoracic legs. These larvæ feed on the manure and in the course of about four or five months each grub grows into a stout fleshy creature measuring about $3\frac{1}{2}''$ to $4''$, the head is brownish and the body, except at the tail end which is dark, has a dirty white appearance with the body segments wrinkled. In its natural position it is always curved up ventrally. The full fed grub constructs a pupal chamber made of soil and excreted matter and changes into the pupa and remains a foot under the soil. The pupal period varies from twenty days to two months. On emerging from the pupa the beetle flies away to the nearest palm trees and starts its damaging work. One generation from egg to adult ordinarily occupies about ten months to a year. Besides coconut, the beetle has been found to attack Palmyra also; it has also been found occasionally on the date and sago palms. Rarely the creature is also found boring into Aloes, Pineapple, Sugarcane and Screw-pine stems. Infestation of trees though perennial is found to be severe during the rainy months. The beetle is a night flying creature and is often attracted by lights.

Control measures.—Both preventive and direct control measures can be adopted, but the former will be found more radical and economical. The preventive methods chiefly consist in tackling the breeding places of the beetle and destroying the early stages of the insect such as eggs, grubs and pupæ. Manure heaps and pits in the vicinity of gardens where the insect often breeds should be periodically examined and the grubs destroyed. Crownless trunks and dead trees should be cut and dried; else the beetle will breed in them. As direct methods of control, the commonest one in vogue in many areas is the practice of examining all the trees periodically and extracting the beetles with a barbed iron hook or wire and the holes filled with sand to prevent further attacks. There are various other local practices which are mostly of doubtful value and cannot compare in economy or practicability with those suggested above. Occasionally another beetle with curious head and thoracic horns in the male (*Xylotrupes gideon*. L.) has been noted in Malabar on coconut in company with the rhinoceros beetle.

THE RED PALM WEEVIL (*Rhynchophorus ferrugineus*, F., *fig.* 264-1 to 4).—This insect is a reddish brown cylindrical weevil with along prominent curved snout. This pest, like the rhinoceros beetle, also enjoys a wide distribution all over this province and Ceylon, though in the Indo-Malayan regions, similar weevils noted belong to different species. Unlike the rhinoceros beetle the adult weevil is incapable of causing any direct damage to the tree, especially because its mouth parts are rather weak and not adapted for work like the former ; on the other hand the early stages of the weevil are passed on the palm and the damage caused to the tree by the weevil larvae is often very serious.

Life history and habits.—The whole life history of the insect is spent on the palm tree itself unlike the rhinoceros beetle. The mother weevil first scoops out a small hole by means of its snout on the soft tissues of the tree and lays inside it an oval whitish egg ; in this way it lays numerous eggs each in a separate hole. The eggs hatch into soft whitish grubs ; these have the head reddish and the body pale yellowish white ; they are footless moving by muscular contractions of the body, and appear as mere lumps of moving flesh. The larvæ feed on the soft tissues of the tree and often cause very severe damage, especially when a number of them bore into the soft growing parts. When full fed, each grub measures about an inch and a half or two in length and becomes yellowish in colour ; before pupation, the grub constructs an elongate oval cylindrical cocoon over its body with fibrous matter and then changes into the pupa. The adult weevil emerges from this cocoon at the end of the pupation period. The male weevil has a tuft of hairs along the dorsal surface of the snout while it is absent in the female.

The insect has been noted on all palms but not so commonly on the coconut palm as the rhinoceros beetle. It is common on the date and sago palms. The weevil is attracted to the trees by the smell of palm juice which flows as a result of wounds caused to the soft parts in various ways—both by human and other agencies. It is said that trees commonly tapped for liquor are more subject to the attacks of the weevil. Dead palms also attract the creature.

Control measures.—In this case also, the measures of control should be devised chiefly in the direction of preventing the insect getting access into a tree for egg laying. All scars or wounds and exposure of the soft parts of a tree should be avoided or properly treated ; dead, headless and felled trunks or stumps of trees which allow the pest to breed should be properly disposed of. Wherever possible, the grubs should be removed from the infested trees and the wounds dressed up with some repellent drug like tar or phenyl water mixed with clay. It is very difficult to save a tree wherein the grubs have gained deep entry and are sufficiently protected from external disturbances.

THE BLACK HEADED CATERPILLAR (*Nephantis serinopa* M., fig. 265).—In many parts of Southern India, next to the rhinoceros beetle, this caterpillar is found to be a very important pest of the coconut palm. It is a slender elongated pale grey caterpillar with a blackish head (hence its name) and is the larva of a medium sized moth with uniform pale whitish upper wings. Though it is found chiefly along the sea board tracts especially of the West Coast, it has also been noted in different interior areas

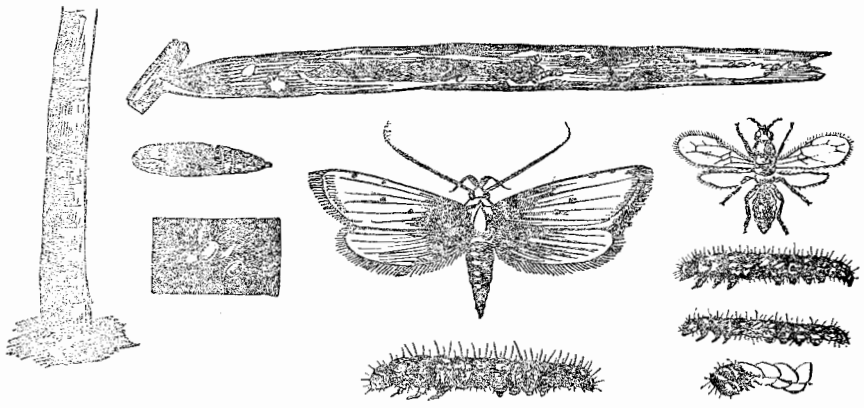


FIG. 265.—BLACK HEADED CATERPILLAR OF THE COCONUT PALM. (*Nephantis serinopa*, M.)

Attacked frond, stages of insect and parasite (Bethylid).

like Coimbatore, Salem, Tiruchirappalli, etc. It is a well known pest of coconut in Ceylon also. The caterpillar lives on the under surface of the leaves in galleries made of silk, and excreted matter, and feeds on the green tissue of the leaf, this kind of injury by numerous caterpillars causes the foliage to dry up and when many fronds are similarly affected on a tree, the latter suffers considerably, and the output of nuts is subsequenlty reduced. Infested trees are easily recognized by the dried up patches in the fronds and the gradual drying up of these parts.

Life history and habits.—The moth lays small batches of scale like eggs along the underside of the leaf, especially near the old larval galleries. On hatching, the caterpiller starts feeding on the green matter of the leaf and at the same time constructs the usual gallery made of silk and frass inside which it generally remains. The caterpillar grows to about an inch when the body assumes the pale greyish green color with the black head; it changes into a brownish pupa inside the same gallery from which the whitish moth emerges at the end of the pupation period. During certain years the pest causes serious damage to coconut plantations; it has been so along the West Coast for the past many years. The pest is found on palmyra palms also. The insect is found subject to the attacks of some natural enemies chiefly wasps—the more noteworty of these are a braconid (*Microbracon serinopæ*, Ram.), an ichneumid

(*Elasmus nephantidis*, R.), a bethylid (*Perisierola nephantidis*, M.) and an eulophid pupal parasite (*Trichospilus pupivora*, F.). During certain seasons these parasites play some active part in controlling the caterpillar pest.

Control measures.—Prompt cutting and burning of the first attacked fronds is the best remedy. But in carrying out control measures of this sort to successful ends, a concerted effort of all the garden owners is necessary. As some of them were not quite willing to co-operate, legislation in the shape of the Pest Act was in force on the West Coast for a few years until the pest was brought under some check. This method of control was augmented to a considerable extent by utilising the help of its natural enemies. Of the number of parasites recorded on the larval and pupal stages of the pest, the larval bethylid wasp *Perisierola nephantidis*—and the eulophid—*Trichospilus pupivora*—attacking the pupae were found easily rearable under laboratory conditions, the latter on alternate hosts also. These were multiplied in numbers in temporary field laboratories established in the midst of the infested area and released wherever necessary. The results have been uniformly convincing and this method of biological control is, therefore, being extended with success to the other parts of the Presidency. The beneficial effects of the colonised parasites have been so remarkable that even the mechanical method of cutting and destroying the affected leaves is being dispensed with in some cases.

Other Insects.—Among other leaf eating insects of coconut may be mentioned two or three species of slug caterpillars which break out as sporadic pests in different areas and give some temporary trouble. The castor slug [*Latoia lepida*, C. fig. 159 (1)] is one of them. In parts of South Malabar and Cochin another slug (*Contheyla rotunda*, H., fig. 266), occasionally gives similar trouble. In the Godavari delta another spiny slug (*Macroplectra nararia*, M., fig. 267) occasionally occurs on coconut and causes some damage. Prompt preventive measures alone will be found effective and economical. Among minor caterpillars of coconut noted in Southern India mention may be made of (1) a notodontid caterpillar (*Turnaca acuta*, W.), (2) the larva of a small beautiful irridescent dark brown gelechiad moth (*Coconympha iridarcha*, M.), and (3) the caterpillar of a tineid moth (*Batrachedra arenosella*, W.), attacking flowers. The leaf eating butterfly caterpillars (*Gangara thyrsis*, M., fig. 268 and *Suastes gramius*, F.) are occasionally found feeding inside coconut leaf folds especially on young plants. The caterpillar is cylindrical and stout and covered with plenty of white waxy floss; the pupa is found in the same leaf fold, and the butterfly has a brown body with yellow markings. This is a minor pest and clipping off of the leaf rolls will easily check the pest. A noctuid caterpillar (*Cyclodes omma*) is found on coconut in Malabar coast. Colonies of a lace-wing bug (*Stephanitis*, fig. 247) and a species of plant lice (*Cerataphis lataniae B.*) are occasionally found on the tender foliage.

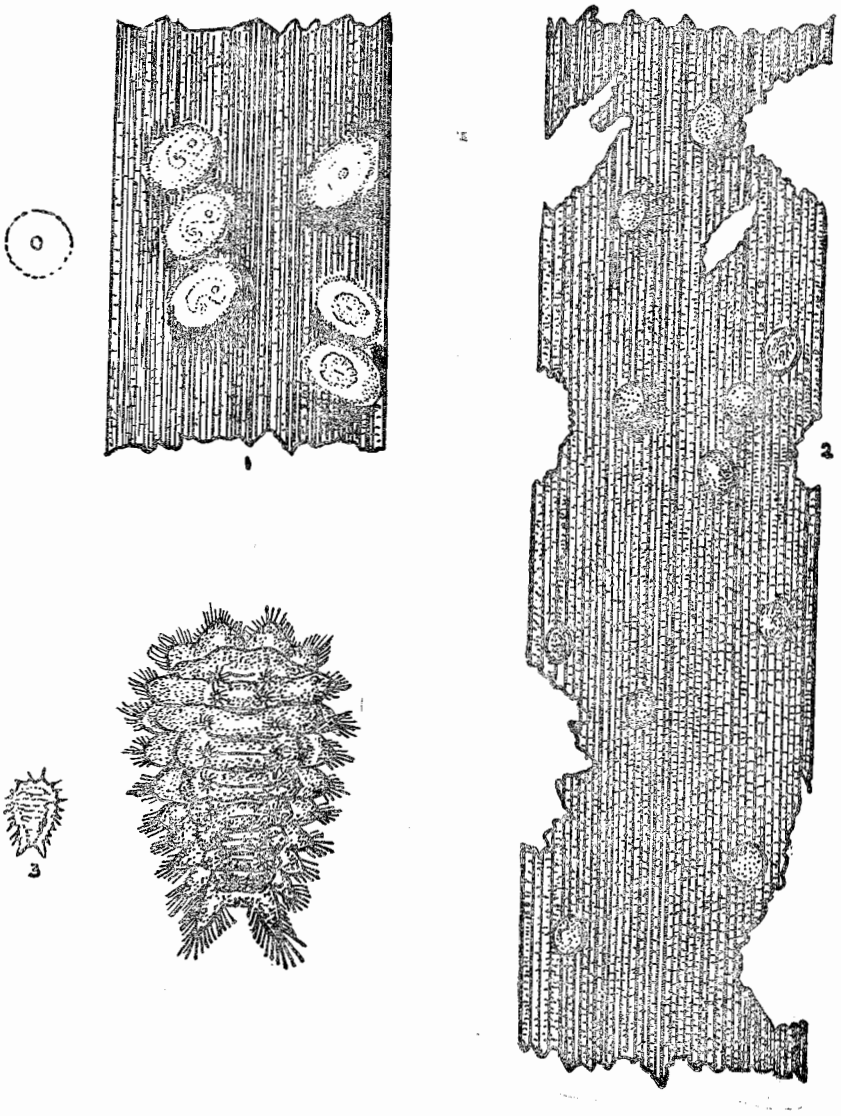


FIG. 266.—THE COCONUT SLUG OF THE MALABAR COAST.
(*Contheyla rotunda*, H.)

1 & 2. Eggs on leaf. 3. The slug caterpillar.

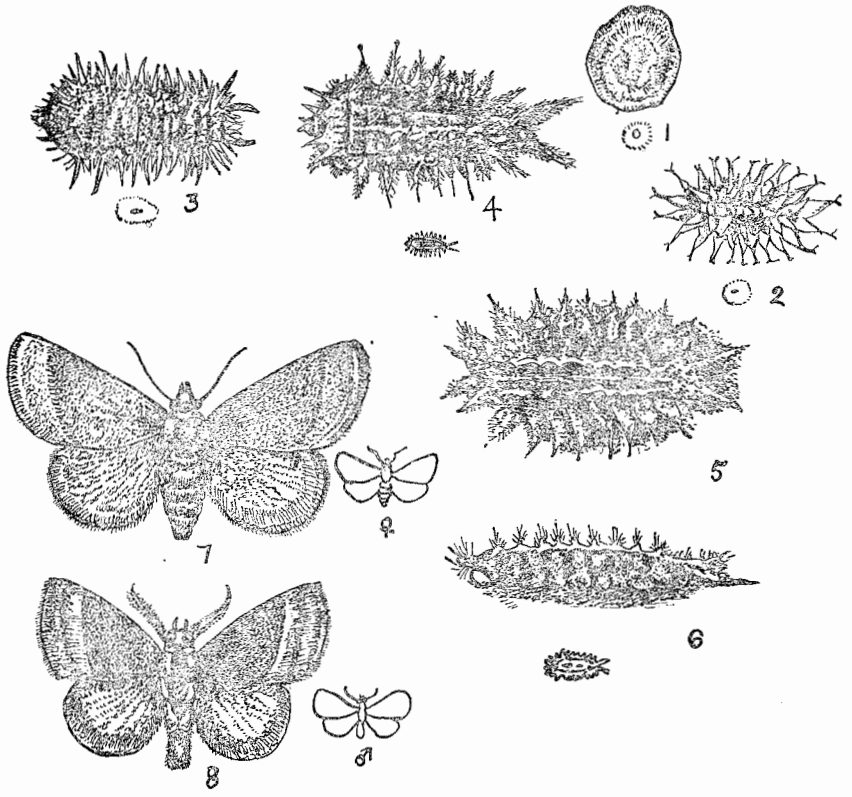


FIG. 267.—PALM SLUG OF THE NORTHERN CIRCARS.
(*Macroplectra nararia*, M.) Stages.

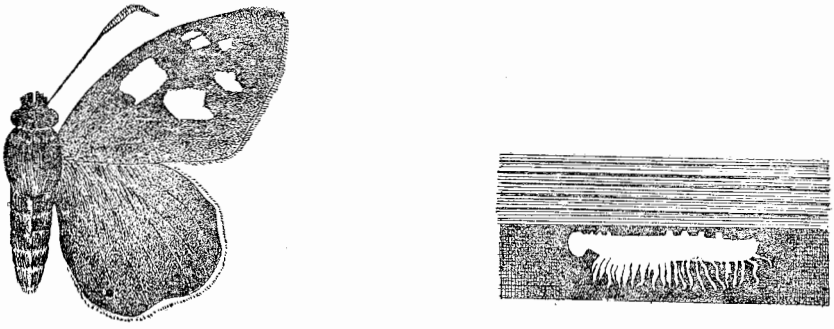


FIG. 268.—THE PALM SKIPPER.
(*Gangara thyrsis*, M.)

1. Butterfly. 2. Caterpillar.

Scale insects and mealy bugs are the other insects which now and then infest coconut. Among scales, the commonest and the one occasionally found doing some serious damage to the leaves, by turning them pale yellow is a hard scale (*Aspidiotus destructor*, S., fig. 269) which has a transparent pale brown circular body. Colonies of this scale are found covering the infested leaves, which gradually turn sickly yellow. Other scales such as *Ceroplastes actiniformis*. G., *Vinsonia stellifera*, W. *Aspidiotus ficus*, A., and *Lecanium hesperidum*, G., are also noted at times but not usually as serious pests.

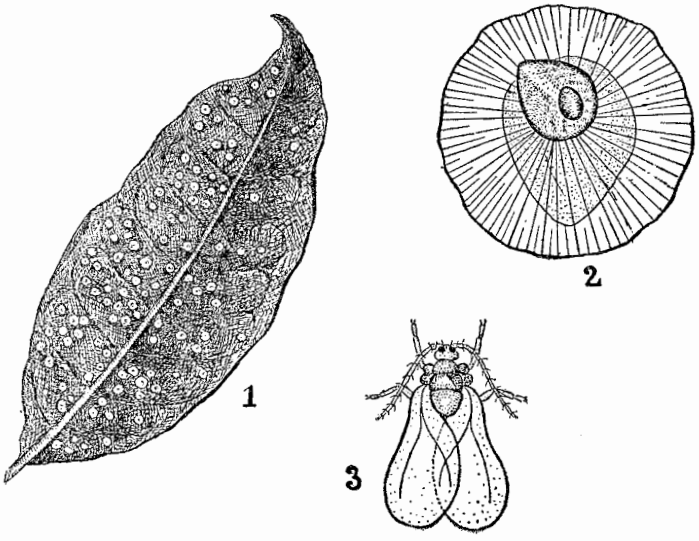


FIG. 269.—PALM SCALE.
(*Aspidiotus destructor*, S.)
1. Scale on leaf. 2. Female 3. Winged male.
[*After Green*]

One or two species of mealy bugs (especially *Pseudococcus* spp.) are occasionally found affecting the central shoots of young plants and checking their normal growth ; ants are found visiting these bugs and helping them to multiply. A wash or two with some contact insecticide will check the pest.

Some minute dark beetles (chiefly the weevil *Calandra stigmaticollis*, G.) and the Scolytid (*Xyleborus parvulus*, E.,). are occasionally seen in holes in the stem ; these do not appear to be pests, but are probably insects following some stem disease. A pale dark weevil (*Dereodus sparsus*, B.). is sometimes noted on the leaves of coconut in South Kanara.

PALMYRA (*Borassus flabellifer*).

Both the beetles and some of the caterpillars noted under coconut affect this palm also. The minor pests include a small brownish smooth leaf beetle (*Wallacea dactylifera*, M.), and an interesting species of thrips (*Kleothrips subramanii*, R.) injuring the foliage.

DATE (*Phoenix sylvestris*).

The red palm weevil (*Rhynchophorous ferrugineus*, F., fig. 264–1–4) is the chief pest noted till now on this tree in South India. The hard scale (*Parlatoria blanchardi*, T.) is a pest of this palm in the Ceded Districts.

ARECA (*Areca catechu*).

This palm is not found subject to any important insect pests. Occasionally young trees are found affected by some scale insects (chief being *Pinnaspis aspidistrae*, S., and *Chionaspis dilatata*, G., fig. 270). The small pale grey arecanut beetle (*Aroecerus fasciculatus*, D., fig. 271) though originally noted on Arecanuts has not been found to any extent on Areca ; often it is found on Coffee berries and Tephrosia pods.

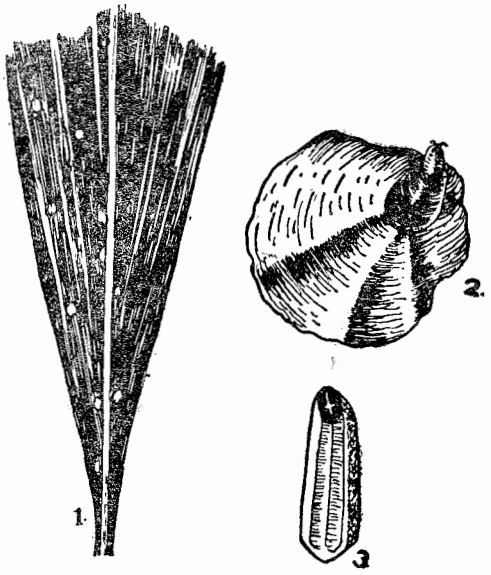


FIG. 270.—SCALE ON ARECA PALM.
(*Chionaspis dilatata*, G.)

1 Scales on palm.
2 Female.
3 Male scale.

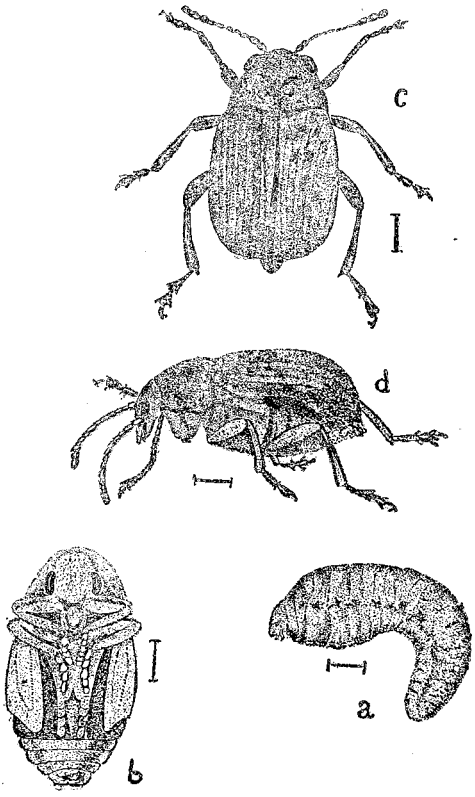


FIG. 271.—THE ARECANUT BEETLE.
(*Aroecerus fasciculatus*, D.)

a Larva.
b Pupa.
c & d Adult.

[*After Lefroy*

CHAPTER XVII.

Pests of plants yielding Dyes, Drugs, Spices, Narcotics, etc.

INDIGO *.

A red and white spotted weevil (*Alcidodes bubo*, F.) which is a specific pest of agathi (see p. 364) is occasionally found breeding in the tender shoots, though it has not been noted as a serious pest till now. Now and then some leaf eating moth caterpillars (chiefly *Laphygma exigua*, H., fig. 123, *Plusia orichalcea*, F., and *Dichomeres ianthes*, M., fig. 272) are found on the crop, the last one it sometimes bad on the crop.

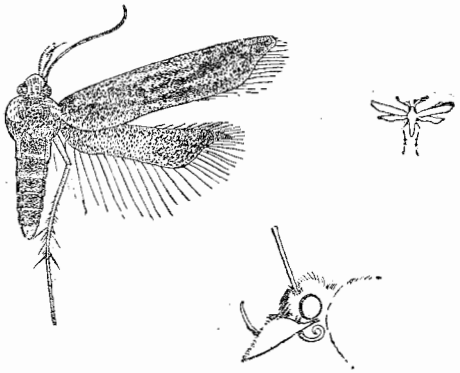


FIG. 272.—INDIGO LEAF ROLLER MOTH.
(*Dichomeres ianthes*, M.) [*From S.S.I.*]

A specific pest of indigo is the Indigo psyllid (*Arytaina punctipennis*, Cr.) a small light brown active jumping bug with spotted wings measuring about 1/12 of an inch. Hundreds of these small bugs in all stages attack the tender shoots and suck up plant sap like plant lice. On the indigo plant this damage causes the leaves around the growing point to curl up and form a twisted knot at the top of the stem ; this damage gradually kills the top shoot. This insect has been noted all over India. Numerous eggs are laid by the mother insect on the tender tissues such as the top leaflets, axils of the leaves, leaf grooves, etc. In about ten or twelve days the eggs hatch into pale yellowish nymphs ; these have the same feeding habits as the parent, and in about three or four weeks these develop wings and assume the adult stage. When the pest is bad, pruning of badly infested shoots and the application of contact insecticides will check it.

* *Indigofera arrecta.*

Turmeric and Arrow Root.*

The most important and a fairly serious pest of these crops is the shoot borer caterpillar (*Dichocrocis punctiferalis*, G., fig. 159–2) —the same insect noted before as the castor capsule borer ; the caterpillar bores into the central shoot and kills it thus causing dead-hearts on affected plants. The turmeric skipper (*Udaspes folus*, Cr.,

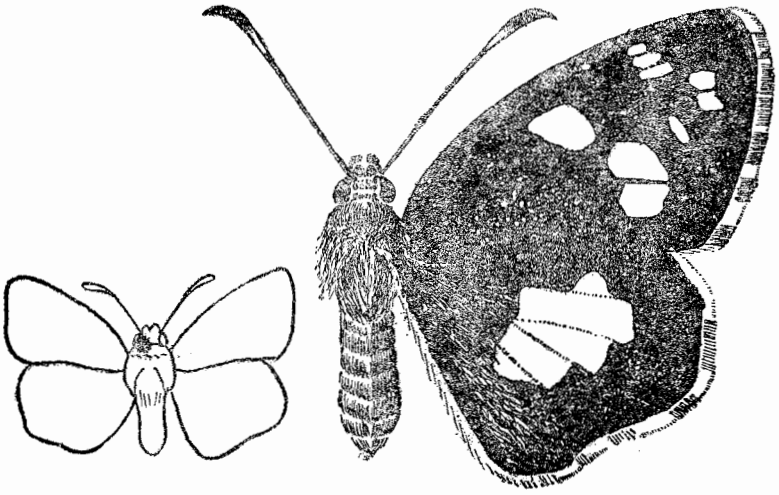


FIG. 273.—THE TURMERIC SKIPPER BUTTERFLY.
[*Udaspes folus*, C.)

[*From S.S.I.*]

fig. 273) a black and white spotted butterfly is a specific pest of these two plants ; the greenish larva remains feeding in leaf folds and pupates inside the same in a thick mass of white waxy stuff. It is not a serious pest and the larva can be easily handpicked. Occasionally, in parts of Malabar, Salem, etc., turmeric haulms have been found infested with colonies of a pale grey hard scale insect (*Aspidiotus hartii*, C.) ; these scales are often distributed with the seed and they sometimes multiply abnormally, and cause damage to the haulms. Selection of healthy seed for planting as a preventive, and mixing of a contact poison with the irrigation water as a direct control measure will check the pest. It has been noted on yams also in some places. A small reddish brown thrips (*Panchaetothrips indicus*, B., fig. 274) which is a specific insect found on turmeric is occasionally found in numbers on both these plants. A small transparent white lace-wing bug (*Stephanitis typicus*, D.) noted under Banana is also sometimes found in colonies on the foliage of these plants causing a sickly and spotted appearance (fig. 247).

* *Curcuma spp.*

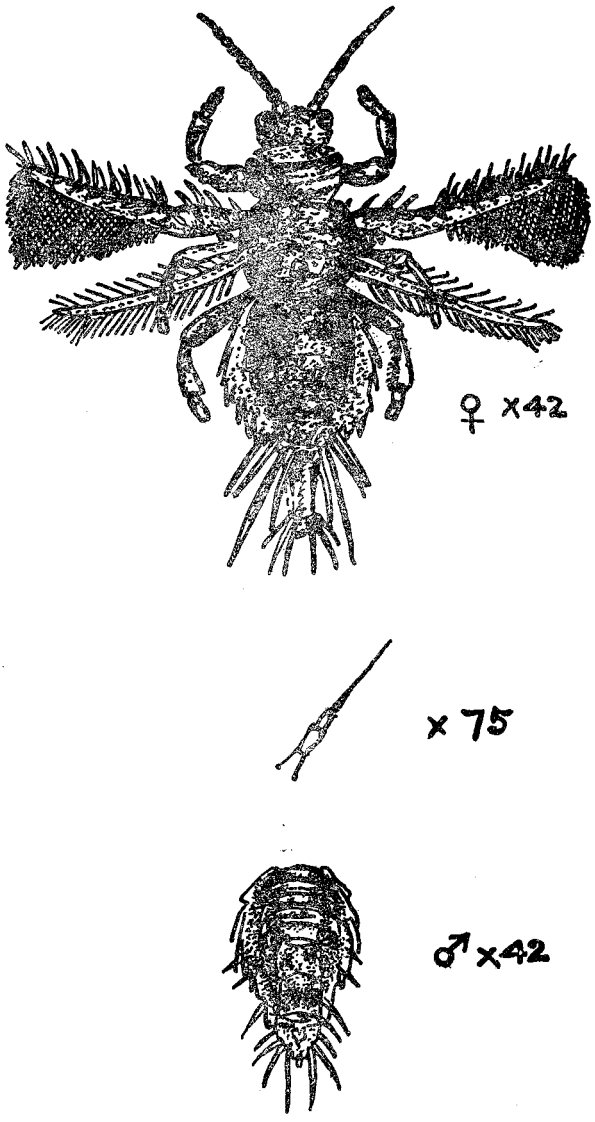


FIG. 274.—THE TURMERIC THRIPS.
(*Panchœtothrips indicus*, B.)
[Female insect, Anntenna and abdomen of insect.]
[*After Bagnall*]

GINGER. *

The shoot borer caterpillar of turmeric (*Dichocrocis*) is found attacking ginger also. Sometimes growing shoots and underground haulms of ginger are also subject to the attacks of some Chloropid fly maggots ; two such flies have been noted in Malabar (*Formosina flavipes*, M., and *Chalcidomyia atricornis*, M.). A similar fly has also been noted sometimes on cardamom.

[CUMMINS, CORIANDER, ANISEED, ETC.

No insects doing any serious damage to these have been noted. So far in South India the casual insects generally found on these plants are some leaf caterpillars (commonly the onion caterpillar—*Laphygma exigua*, H.) and some stink bugs on the flower heads such as (*Agonoscelis nubila*, F., fig. 275) and allied species. A species of plant lice (*Brevicoryne corianderi*, D.) is sometimes noted on coriander flowers in Coimbatore.

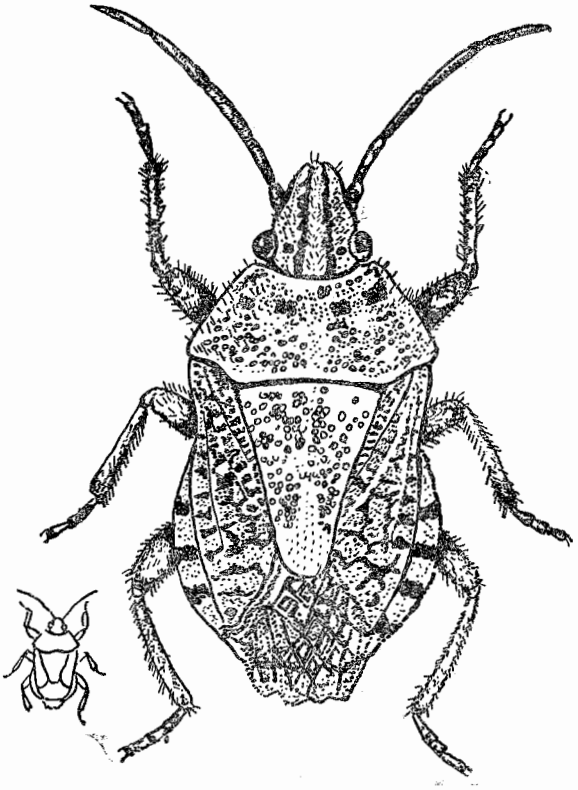


FIG. 275.—FLOWER HEAD BUG.
(*Agonoscelis nubila*, F.)

[*From S.S.I.*]

* *Zingiber officinalis.*

Pepper Vine.*

Pepper flea beetle (*Longitarsus nigripennis*, M., fig. 276).—The most important and specific pest of the pepper crop, which is chiefly grown only along the Western Ghats, is a small shining yellow and blue flea beetle—called the pepper Pollu beetle which is about a tenth of an inch in length. It has the hind legs stout and is capable of jumping long distances like grasshoppers. The small pale yellowish grub of this creature bores into the ripening pepper berry, feeds on the seed and makes the berry hollow; sometimes appreciable damage is caused to the pepper crop. The insect is found chiefly in North Malabar and to some extent in the Wynaad.

Life history and habits.—Eggs are deposited by the mother beetle, each into a small hole made by it on the rind of a green tender pepper berry. In about a week or ten days the eggs hatch into pale yellowish grubs which have three pairs of legs and well developed jaws. These feed on the berry contents and gradually grow in size; before becoming full fed, one grub generally damages two or three berries in a spike. The grub becomes mature in about a month. At this stage, it is 1/5 inch in length and has a yellow body and dark head region. When full fed the grub drops into the soil and changes into the pupa in a pupal chamber made of soft soil. In another week the adult beetle emerges out of the pupa. The work done by the grub not only affects the berries in a spike, but often the stalk of the whole spike. Attacked berries can be made out by the pale sickly dark colour of the attacked berry and also by the small hole on its surface. Other flea beetles occasionally found on pepper leaves in Malabar are *Pagria costatipennis*, J., and *Neculla pollinaria*, B.

Control measures.—It will be found difficult to check this insect if it appears as a serious pest; but very rarely has 'pollu' damage to pepper been caused by insect agency alone. In tracts where the pest appears as a regular pest, year after year, precautions may be taken to hoe the soil well to kill the underground pupæ and spray the spikes with a repellant mixture like Bordeaux mixture.

Pepper scale.—Another pepper pest which is also specific to this vine is a hard scale insect—the pepper scale (*Lepidosaphes piperis* G., fig. 277); this is a small dark grey boat shaped scale found in millions on the main stems and leaves of infested vines; badly infested vines gradually dry up. The insect, for all outward appearance, appears a lifeless minute piece of scale but causes appreciable damage at times. This pest is bad in parts of Travancore and Wynaad. The only remedy in a bad attack is to prune and burn badly infested vines and spray the rest with a strong contact wash. The large soft scale insect (*Marsipococcus marsupiale* G., fig. 80) also occasionally covers the foliage and vines and causes some damage in parts of Coorg. The common mealy bug (*Ferrisiana virgata*, C.) is also occasionally found on pepper, but is very rarely so serious as the scales, (fig. 218).

* *Piper nigrum.*

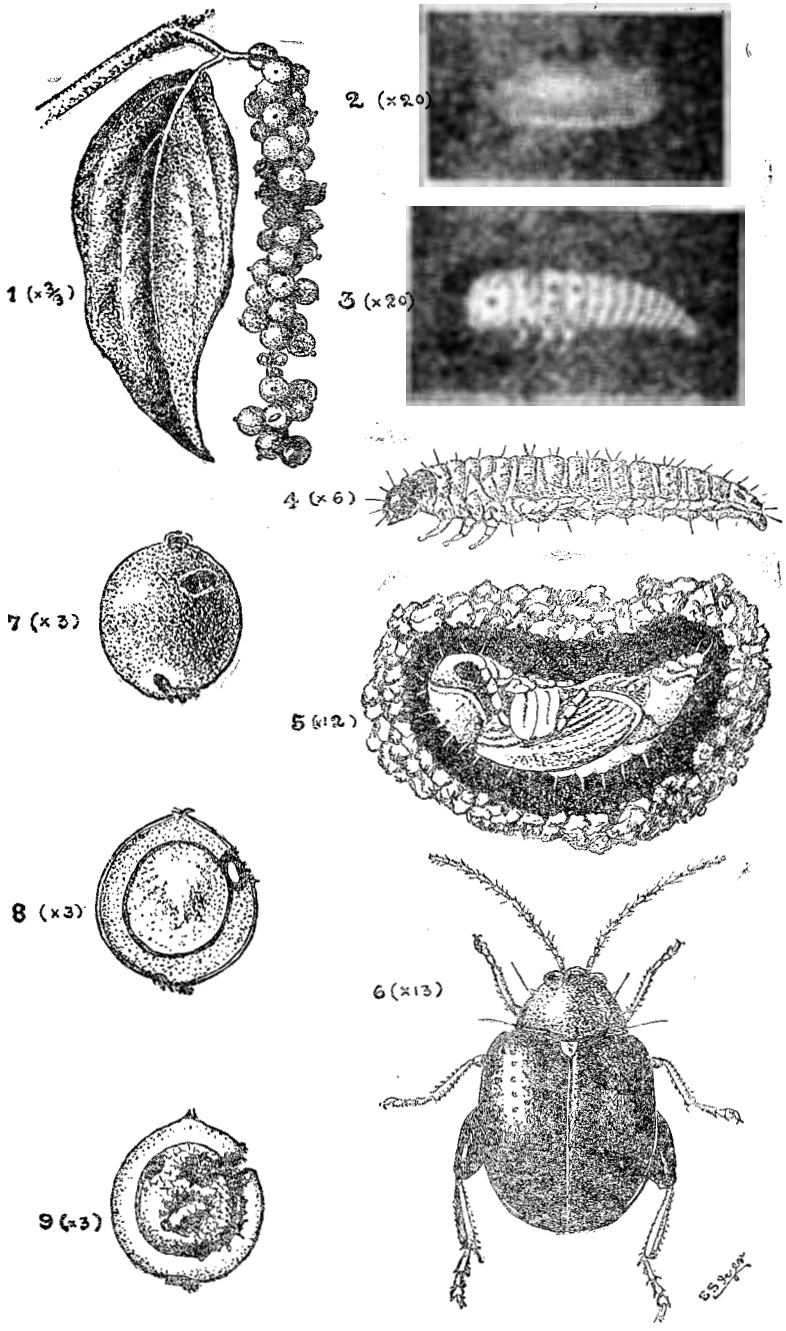


FIG. 276.—THE POLLU BEETLE OF PEPPER.
(*Longitarsus nigripennis*, M.)
1 Attacked pepper spike. 2 to 6 Stages of beetle.
7 to 9 Damage in berry.

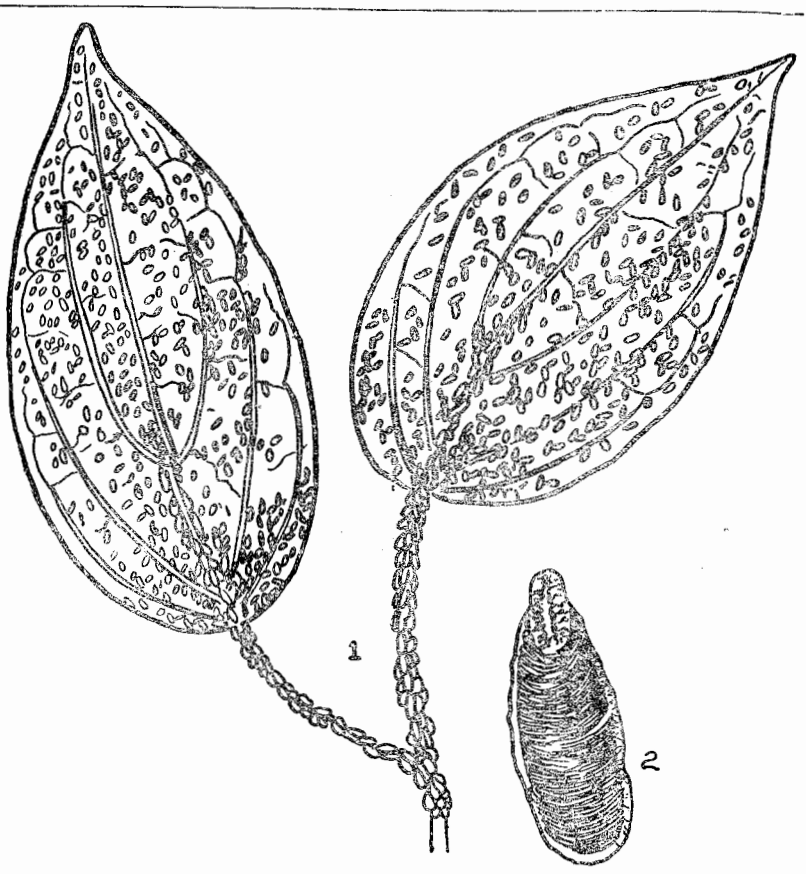


FIG. 277.—MUSSEL SCALE OF PEPPER.
(*Lepidosaphes piperis*, G.)

1. Infested pepper leaves. 2. Female scale.

The wild hairy silkworm (*Cricula trifenestrata*. H.) noted under mango and cashew is sometimes noted as a minor pest on pepper leaves. (fig. 261).

Betel Vine (*Piper betel*).

The important pest of this plant is the betel vine bug (*Disphinctus politus*, W. fig. 278) a slender active reddish brown capsid bug measuring half an inch in length. So far it has been noted only in parts of the Ceded districts, Nellore, West Godavari and South Kanara. It is rare or absent in other betel vine areas such as Coimbatore, Tanjore, Madurai, South Arcot, etc. Outside this province, it has been noted in the Southern Mahratta country and also in the Nizam's Dominions. The insect causes damage to the tender leaves both in the adult and young nymphal stages by puncturing the tender tissues and sucking up the juice from them, this causes the leaves to shrivel and in some cases to fade and dry up. In some areas the loss is very

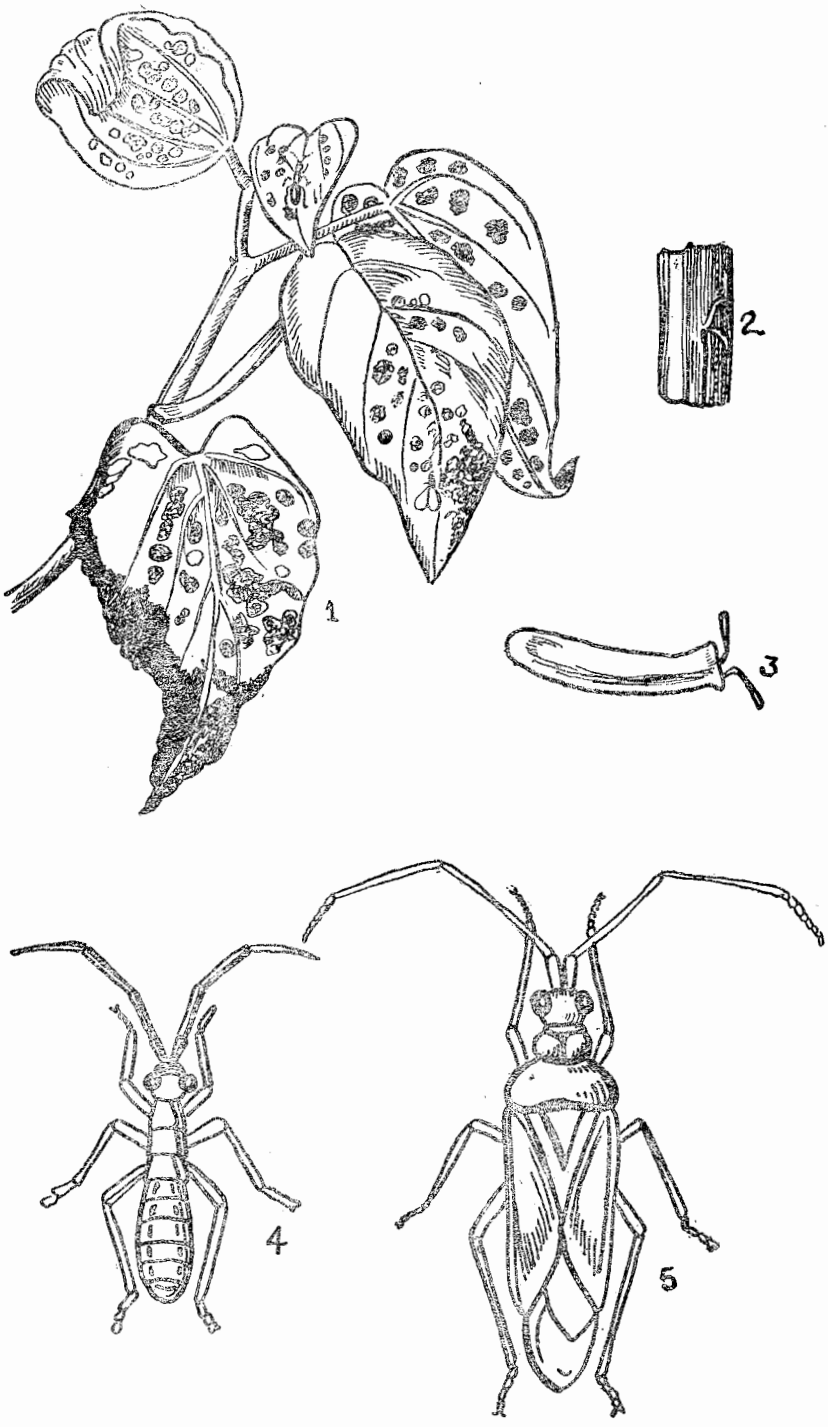


FIG. 278.—BETELVINE BUG.
(*Disphinctus politus*, W.)
1 Damaged leaves. 2 & 3 Egg. 4 & 5 Immature and mature bugs.

substantial. The female insect thrusts each egg into the tender plant tissue by means of its sharp ovipositor just as in the case of the cholam earhead bug *Calocoris* (both of them belonging to the same group and having similar habits); position of the egg inside the tissue can be made out by trained men by the slender hair like processes of the egg which project out on the surface. The active young insects are like the parent except that they have no wings and are smaller in size. This is an insect rather difficult to control in bad infestations. Mechanical methods like netting and trapping the adults and nymphs with sticky winnows or cones employed in time, and sprays of some repellent mixture will give some relief. Recently, DDT and BHC both in the form of spray and dust have given very promising results towards the control of this pest. The effective checking by such measures wants a good deal of co-operation among neighbouring cultivators. Occasionally betel vine is attacked by scales and mealy bugs also (*Lepidosaphes cornutus*, G. and *Pseudococcus* spp.). The betel vines sometimes suffer from root nodules caused by eel worms as on tea, pepper, etc. (fig. 403)

Cardamom (*Elettaria cardamomi*).

The shoot borer caterpillar of turmeric and ginger (*Dichocrocis*) is one important pest of this crop occurring now and then in different parst of South India. A minute reddish brown capsule borer beetle (*Scolytid*, fig. 279) was once reported from Coorg. Recently however, serious damage caused by a species of thrips (*Tæniothrips cardamomi*, R., fig. 280) till now unrecorded has been reported from the Anamalais and cardamom areas in Travancore. Thousands of these small creatures are found to infest the growing flowers and buds, suck up the juice and cause malformation of the capsules, and the

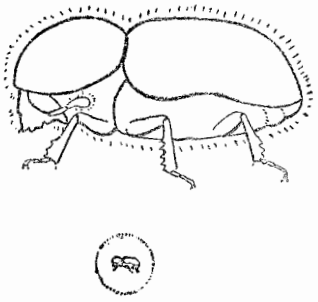


FIG. 279.—CARDAMOM BORER.

[*From S.S.I.*]

result is the drying up of badly infested spikes. Recent investigations have definitely proved the specific action of BHC dust 5% against this thrips. It has been noted on plants like *Colocasia*, *Musa*, *Alocasia*, etc., on the Anamalai hills.

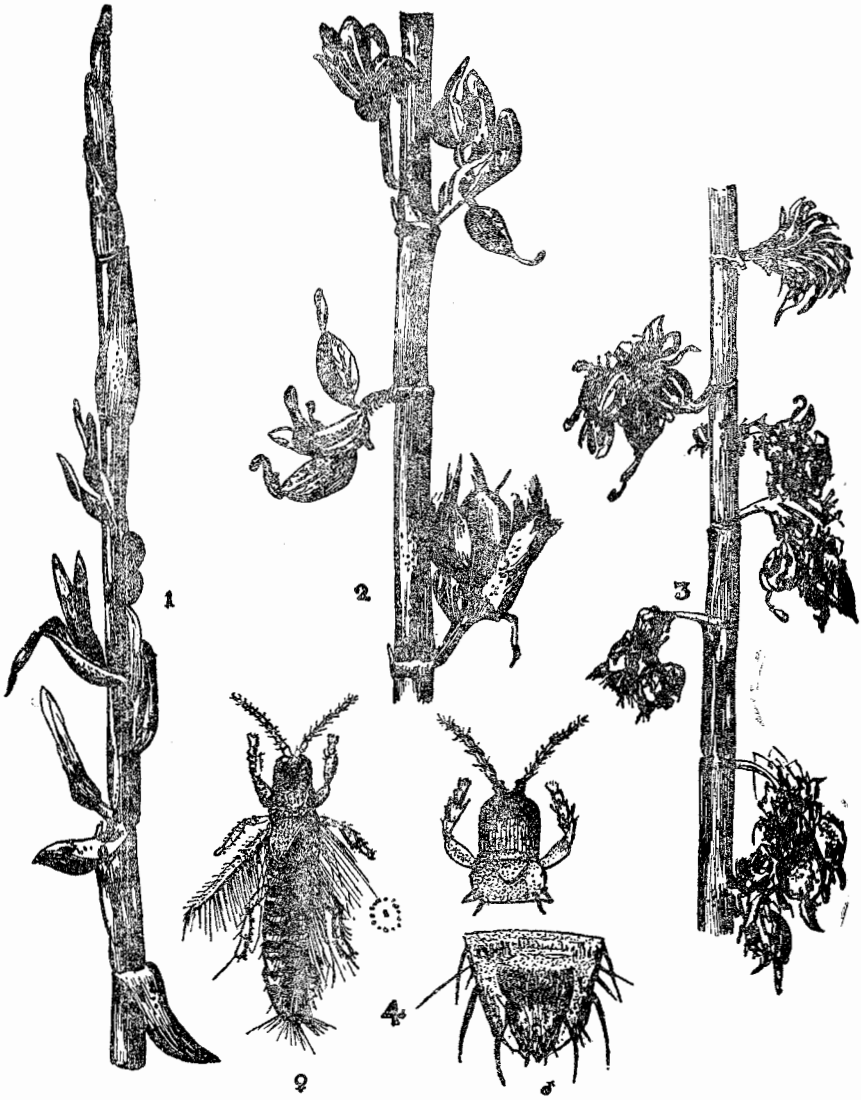


FIG. 280.—THE CARDAMOM THRIPS.
(*Tæniothrips cardamomi*, R.)
1 to 3 Damaged plants. 4 Thrips, male and female.

The cardamom weevil. (*Prodioctes haematicus*, Ch.). This is another injurious insect noted on cardamom; the grub of this weevil tunnels into the rhizome and shoots and often causes severe damage. The insect is ½″ long brownish in colour with stripes and spots on the elytra. A hairy caterpillar (*Eupterote canaraica*) is also noted as a minor pest of cardamom along the West Coast areas and Coorg.

Tobacco (*Nicotiana tabacum*).

The important pests of cultivated tobacco in South India are the leaf caterpillars, stem and capsule borers and plant lice. These are found in all the important tobacco areas. There are a few minor insects also noted occasionally.

The Tobacco Caterpillar (*Prodenia litura*, F., fig. 281).—This is the most serious caterpillar pest of tobacco all over the province. It is a well-known insect found feeding on many other crops like castor, banana, agathi, tomato, etc. The stout dark brown cylindrical smooth caterpillar is a night feeder on the foliage and is one of the insects known as cutworms. In bad infestations, severe damage is done both in the nurseries and the planted fields. The adult insect is a stout dark moth with wavy white markings on the upper wing; it is very closely allied to the paddy army worm, the cholam shoot caterpillars and the potato cutworm, *vide* fig. 83.

Life history and habits.—Eggs are laid on the tender leaves in masses covered with brown hairs shed by the mother insect; each mass contains numerous eggs. These eggs hatch in about four or five days and the small darkish caterpillars start feeding on the soft green layers of the leaf; they generally feed gregariously during the earlier stages, and as they grow in size they become isolated and show hiding propensities as typical cutworms. By the time the caterpillars assume their full grown stage, the body color becomes pale greenish brown with dark markings. Variations in colour are also noticed—some having transverse and longitudinal grey and yellow bands, others with rows of dark spots, etc. In about a fortnight or three weeks, the caterpillar is an inch and a half long and stout built. At this stage, it goes under the soil and changes into the reddish brown pupa inside a rough earthern case; after another fortnight the adult emerges from the pupa. One life cycle of the insect occupies about thirty to forty days. The caterpillar is a very voracious creature and if overlooked, numbers of them will defoliate a whole field in one night.

Control measures.—Though it is a serious pest, it is one of those insects which can be easily controlled. The measures suggested are (1) collection and destruction of the eggmasses which are easily found out, and (2) the clipping of the leaves containing swarms of

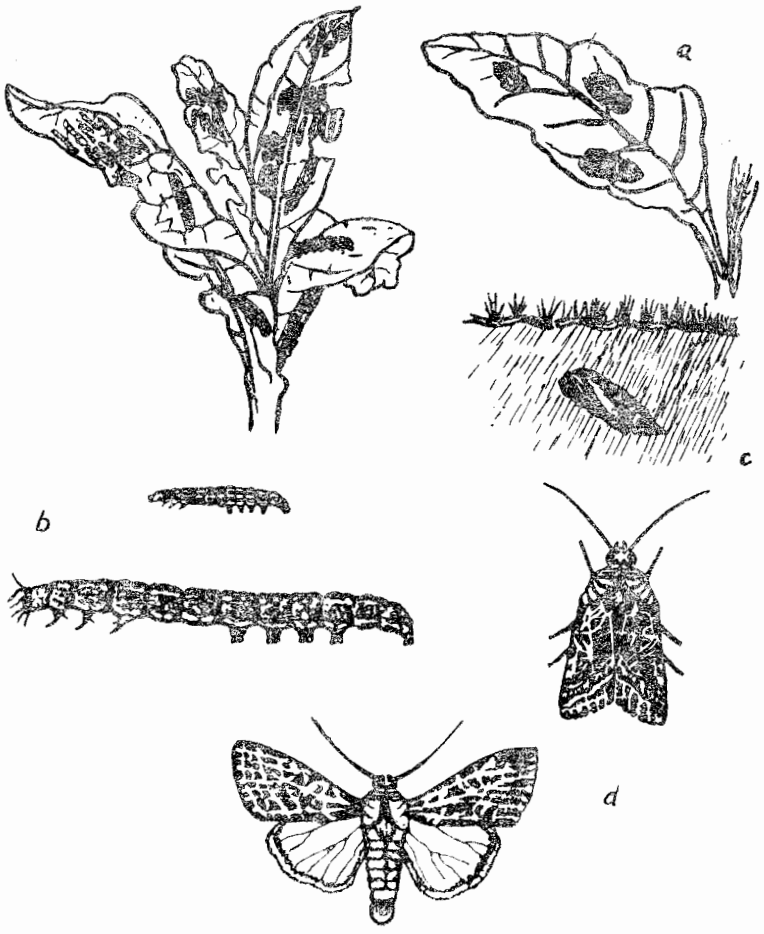


FIG. 281.—THE TOBACCO CATERPILLAR.
(*Prodenia litura*, F.)

a Egg masses on leaf.
b & *c* Larva, pupa.
e Caterpillars on plant.
d Moths.

young caterpillars which feed gregariously ; these two methods alone, if properly attended to, will considerably check the pest. When these methods are not adopted in time and the caterpillar has spread wide, it can be both trapped by poison baits or killed by stomach sprays. Cultural methods like flooding the field wherever possible to bring up the hiding caterpillars, digging trenches to prevent the pest from migrating to another field and ploughing up the field to kill pupæ are all measures which can be adopted whenever possible.

Of the other leaf eating caterpillars found on tobacco the two common ones are larvæ of a couple of stout moths, the green stout caterpillar (*Heliothis assulta*, G., fig. 282) and the semi-looper caterpillar (*Phytometra signata*, F., fig. 283 a and b) which are similar in habits to the gram and snake gourd caterpillars.

The onion cutworm (*Laphygma exigua*, H.B.) This is another pest which often flares up into prominence. A particularly severe damage was recently reported on the nurseries of valuable varieties of tobacco at Chirala. Arsenical sprays were not quite effective, since the poison deposited on the leaves was found to be washed away by the frequent overhead splashes of irrigation, which are so necessary for the proper growth of the seedlings. A simple expedient by way of growing cheap trap crops was devised and adopted

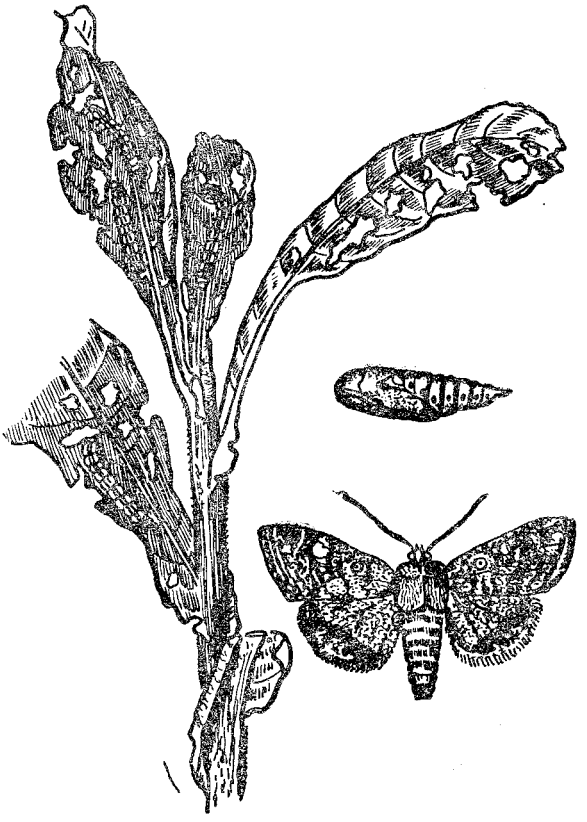


FIG. 282.—GREEN LEAF CATERPILLAR OF TOBACCO AND STAGES.
(*Heliothis assulta*, G.)

with success. The pest is partial to ragi also. Successive beds of this millet were raised in lines around the nurseries and numerous eggs and caterpillars of this insect were found on this trap crop. The collection and destruction of these stages was but a simple and cheap affair.

THE TOBACCO STEM BORER (*Phthorimoea heliopa*, L., fig. 283 c—g.).—In some tobacco areas, the crop suffers from the attacks of a small brownish white stem boring caterpillar. The full grown caterpillar is about half an inch long. The stems of the attacked plants become swollen, and the presence of such gall-like swellings on the stem indicate the work of this insect. The adult is a very

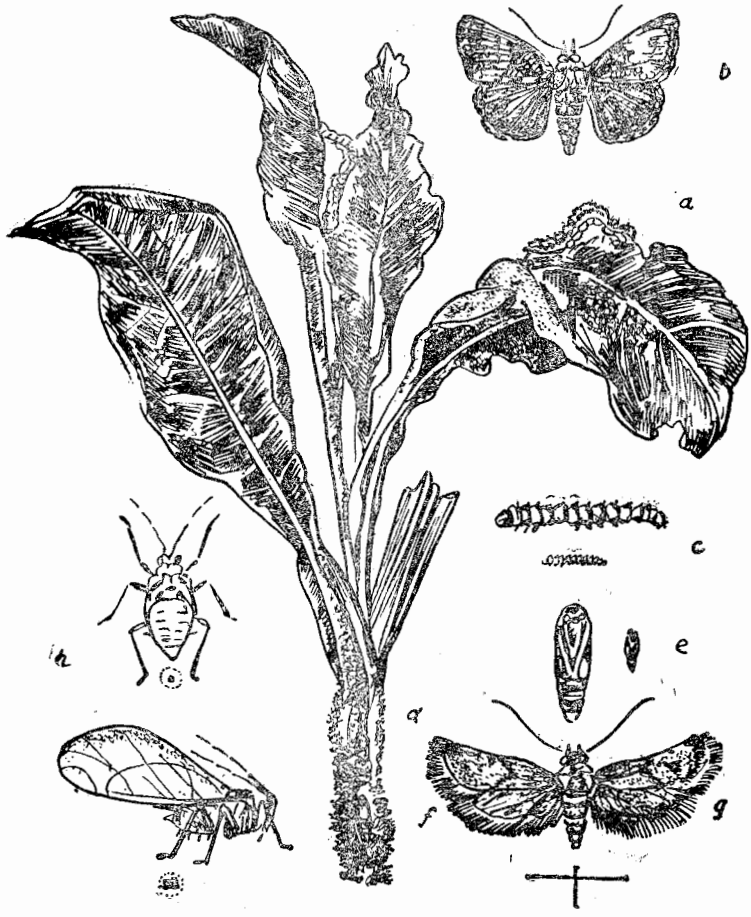


FIG. 283.—STEM BORER, SEMILOOPER AND APHIS ON TOBACCO.

a & *b* Semilooper (*Phytometra*). *h* Aphis (*Myzus*).
c—*g* Borer stages (*Phthorimœa*). *i* Aphis infested leaf.

small active brown moth very closely allied to the potato tuber moth. It has been found as an important pest chiefly in the Northern Circars and the Ceded Districts.

Life history and habits.—Eggs are generally laid on the leaf stalks and the tiny caterpillars, when they hatch burrow along the leaf stalks into the stem feeding on the internal tissues. The irritation caused inside the stem by the larva causes gall like swellings on it. The small reddish brown pupa is also found in the larval galleries inside the attacked stem. One life cycle roughly occupies about seven to eight weeks.

Control measures.—These are mostly preventive. In the nurseries the young plants may be covered at night with sheets or some matting to prevent egg-laying. Plants found attacked in the nursery should not be taken for transplanting in the fields; all infested seedlings should be destroyed. If found in the fields, infested plants should be destroyed or operated carefully with a knife to kill the borer inside. Soon after harvest, the stubble which is often found badly infested should be pulled out and burnt or buried deep.

The well known gram caterpillar (*Heliothis armigera*, F., fig. 284) noted before under redgram, etc., is often found as a seed capsule borer on tobacco in different tobacco areas. Covering the flower stalks with a loose bag will prevent the damage; if this is not done as a proventive the boring caterpillars will have to be handpicked or a stomach insecticide powder may be dusted on the seed heads.

FIG. 284.—SEED CAPSULE BORER IN TOBACCO.
(*Heliothis armigera*, F.)

a Caterpillars on plant. *b* Pupa in soil. *c* Moth.

TOBACCO APHIS—(*Myzus persicae*, S., fig. 283 *h*, *i*).—Tobacco is subject to the attacks of plant lice in all the areas in South India, and during some years severe damage is caused to the crop in parts of Coimbatore, Tanjore, Madurai, Guntur and the Godavari lankas. The species chiefly concerned is the well known green aphid (*Myzus persicae*, S.) which has a world-wide distribution. It is also found on some Cruciferous plants. Badly infested plants appear very sickly, with the leaves curled up and fading; when such leaves are examined, hundreds of the louse in all stages can be found on the surface. These small creatures multiply enormously in a short time and the whole field become rapidly infested. Next to the tobacco caterpillar more complaints have been received about this pest. Control measures consist in clipping and burning badly infested leaves and giving the rest a wash with tobacco decoction.

Other sucking insects of tobacco include (1) a small active greenish yellow bug (*Engytatus tenius* R., fig. 285) which

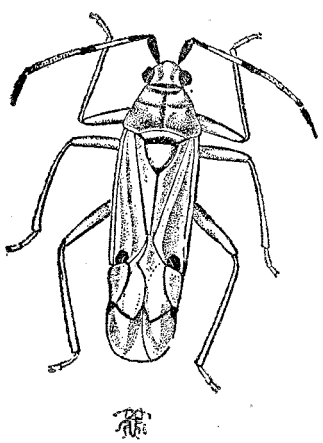


FIG. 285.—TOBACCO CAPSID.
(*Engytatus tenius*, R.)]

sometimes appears like swarms of mosquitoes on the leaves and sucks up the sap from the foliage, and (2) a medium sized reddish brown flattish plant bug. (*Stibaraopus tabulatus*, S., fig. 286) noted as a root sucker in parts of North Coimbatore; the external indication of the presence of this pest in the field is the gradual fading of some plants as a whole and the stunted growth in others. When

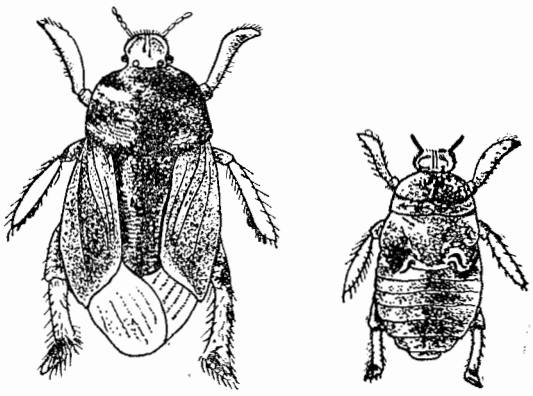


FIG. 286.—TOBACCO ROOT BUG.
(*Stibaraopus tabulatus*, S.)
Mature and immature bugs.

such plants are pulled out, the bug will be found in all its stages clinging to the roots and rootlets of such plants. To check this pest, the irrigation water may be mixed with a contact insecticide like Crude oil emulsion or Fish oil soap. The mosquito bug will submit to handnetting or contact sprays.

A few grasshoppers occasionally affect tobacco ; these include (1) the green tobacco grasshopper (*Atractomorpha crenulata*, F., fig. 287) found as a leaf eater in all stages of the tobacco plant, and (2) a small soil colo red stout built surface grasshopper (*Chrotogonus robertsoni*, B., fig. 84) which causes some appreciable damage in nurseries and to young plants like cutworms. These grasshoppers can be collected with nets or trapped with poison baits. Dusting with BHC 5% has been found to cause a very high death rate on these grasshoppers.

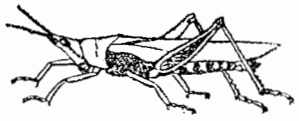


FIG. 287.—TOBACCO GRASSHOPPER.
(*Atractomorpha crenulata*, F.)
[*From S.S.I.*]

Two small dark coloured ground beetles (*Opatroides frater*, F., and *Seleron latipes*, G.) have been noted as minor pests nibbling young tobacco plants in the Guntur area.

GANJA (*Cannabis sativa*).

This is a crop which is cultivated in restricted areas. A few insects are occasionally noted to cause some appreciable damage to this plant. These include the well known gram caterpillar (*Heliothis armigera* F.) already noted under Redgram, Tobacco, etc. This

feeds on the foliage. In a crop like Ganja where the leaf is the final product, it is not advisable to spray any arsenicals against this pest. As such, the only measures possible in this case are of a preventive nature. These include prompt picking off of the first appearing caterpillars and wherever possible, covering the growing plants with a big mosquito net which will prevent moths from approaching the plant and laying eggs. This might, perhaps, be found to be an economic proposition against this pest only in the case of this crop which fetches a substantial revenue. There are a few other caterpillars occasionally found with the gram caterpillar (such as *Amyna octo*, *G.*, *Laphygma exigua*, H., and *Prodenia litura*, F.). Other pests of ganja include white ants (*Microtermes obesus*, R.) which attack the roots, a small black thrips (*Heliothrips indica*, B.) sucking the sap from the tender shoots and buds, and a minute mite (*Tetranychus telarius*, Z.) which is sometimes found as a serious pest of this crop.

Cinnamon (*Chinnamomum ceylanicum*).

Since there is no regular cultivation of Cinnamon on any large scale in this province we know very little of the insects injurious to this plant. So far as the writer has been able to examine on plants found in different parts of the Western Ghats, he has noted a small leaf mining moth caterpillar (*Phyllocnistis chrysophthalma*) and a leaf attacking jumping bug (*Pauropsylla depressa*, *C.*); this latter is an insect more or less similar to the one noted on fig. leaves (fig. 34); the larvæ and the adults cause galls on the leaves and shoots.

On trees like Camphor, Nutmeg and Cloves which are not widely cultivated trees, a few species of a soft scale (*Lecanium*) have been noted in places like Courtallam, Kallar, Kodaikanal, etc.

Coffee.

This crop grown on a large scale in the hill plantations of South India is subject to some insect pests. The more important of these are—

The Coffee White Borer—(*Xylotrechus quadripes*, Ch., fig. 288).—This is the most important and serious of all coffee pests in South India. The insect is a dark brown longicorn beetle having a number of whitish marks on the thorax and upper wings. It measures about a third of an inch in length and has an elongate cylindrical body, with well developed antennæ and legs. Injury to the coffee plant is caused by the white grub of this beetle boring into the stem and branches and often killing them. In some estates, very severe loss is sometimes caused by this pest, and due to this severe damage caused year after year, some of the estates have to be replanted or even given up.

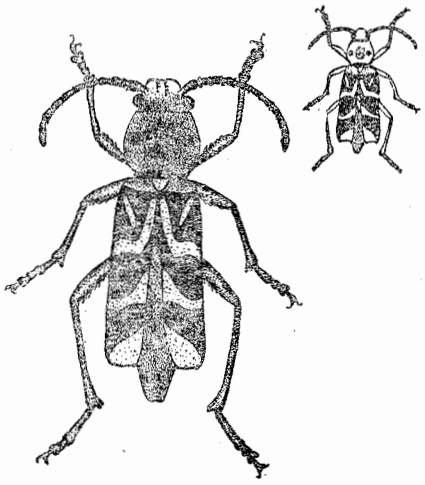


FIG. 288.—THE WHITE BORER OF COFFEE
(*Xylotrechus quadripes*, C.)

[*From S.S.I.*]

Life history and habits.—The mother beetle lays eggs in cracks and crevices on the plant stem and a number of them are laid by each female. The eggs generally hatch in about ten days. The just hatched grub commences boring into the bark and remains tunnelling into the stem for about nine months. When full fed it is ¾ inch long and has a pale yellow colour ; in form it is stout and swollen towards the head end and tapering towards the tail when about to pupate, it makes an emergence hole on the surface and then changes into the pupa in a pupal chamber made close to the surface to help it to come out easily on assuming the adult stage. In about a month's time the adult beetle emerges. It has been found that coffee bushes which are young suffer more than older ones and die in numbers, though in the case of the latter they lose their vigor and yielding capacities considerably.

Control measures.—All measures have to be directed to prevent the beetle from laying eggs on the stem. Proper scraping of the stems once or twice during the egg-laying season with strong brushes would destroy the eggs and just hatched grubs. Proper disposal of dead wood often containing the beetle grubs should also be attended to. Adult beetles can be also collected and destroyed.

Green and Red bugs—(*Lecanium viride*, G., and *Saissetia hemisphericum*, T.).—Next in importance to the white borer are these two notorious scale insects. The green scale is the more destructive of the two ; colonies of this flattened green insect are found in all its stages on the tender shoots and foliage. On account of the drainage of plant sap the shoots become weakened and, due to th sweet secretion by the scales, the leaves become covered with black blight. In some areas, as in some estates in Ceylon, the pest causes very serious harm. The brown hemispherical scale which is also

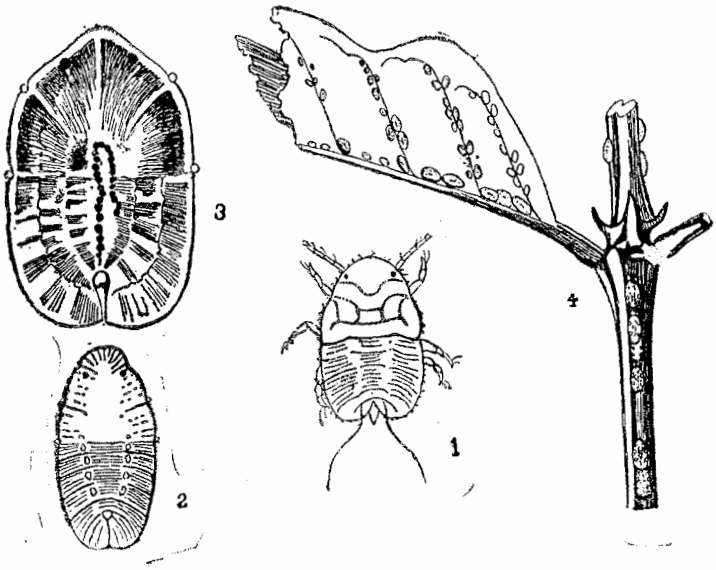


FIG. 289.—GREEN BUG OF COFFEE.
(*Lecanium viride*, G.)

1 to 3. Stages of bug. 4. Infested plant.

[*After Green*]

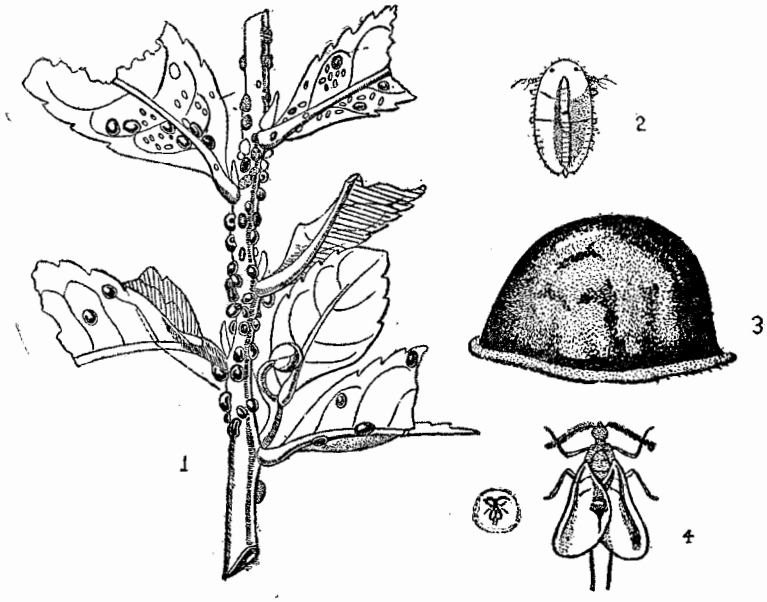


FIG. 290.—THE BROWN SCALE OF COFFEE.
(*Saissetia hemisphericum*, T.)

1 Scales on plant.
2 Larva.
3 Adult female.
4 Male.

[*After Green*]

similar in habits is not so destructive. Proper precautionary measures in the shape of pruning, attention to other plants on which these bugs breed and spraying of contact washes at the proper time will be of help in controlling these pests (figs. 289 and 290).

Occasionally species of shot hole borer beetle (chiefly *Xyleborus morstatti*, E., and *X. compactus*, E.) cause damage to the tender branches and leaf stalks of growing coffee as on tea. (fig. 297); the infested stalks which show small holes from which powdery matter is thrown out by the insect inside gradually dry up and die. It is sometimes bad in parts of Wyanad.

There are numerous other insects found feeding on coffee but they are all of minor importance and very rarely prove serious. These include—

(1) Leaf eating caterpillars of different kinds of moths including smooth cut worm caterpillars (*Agrotis sp.* and *Euxoa segetum*, S., fig. 83-4), a slug caterpillar (*Belippa laliana*, M.), a hairy caterpillar (*Olene mendosa*, H.) and the small flush-worm (*Homona coffearia*, N. fig. 291); this is very rarely noted.

(2) Leaf beetles—cock chafers (*Holotrichia conferta*, S., *Serica pruninosa*, B., etc.), the grubs of which attack the roots, weevils chiefly (*Sympiezomias frater*, M.) and metallic leaf beetles (chiefly *Carinodes sheppardii*, B.) feeding on the foliage.

(3) The coffee leaf hopper (*Ricania bicolorata*, D., figs. 10, (11) p. 20), an active black moth like bug, dark brown in colour, found in thousands on coffee, citrus and other plants during the summer months on the Nilgiris slopes, the younger stages of the insect are profusely covered with waxy filaments and colonies of them cover the foliage.

(4) The coffee plant bug (*Antestia cruciata*, F., fig. 303), an oval flattish stink bug found sucking sap from the shoots and tender berries; not serious in South India but is reported to be a very bad pest in Africa. It is found on jasmine also in the plains.

(5) Coffee berry borers—The arecanut beetle noted before (*Arœcerus fasciculatus*, D., fig. 271) is commonly found attacking the ripening berries. The serious exotic pest (*Chryphalus hampei*) known as a bad borer of coffee berries in other countries has recently been found in India also and precautions are being taken to prevent its entry. It is a minute brown shot hole borer beetle (fig. 75).

(6) The coffee grasshopper (*Aularches miliaris*, L., fig. 292). —A pretty dark green grasshopper, though found in the plantations in South India, has not been noted as a pest yet.

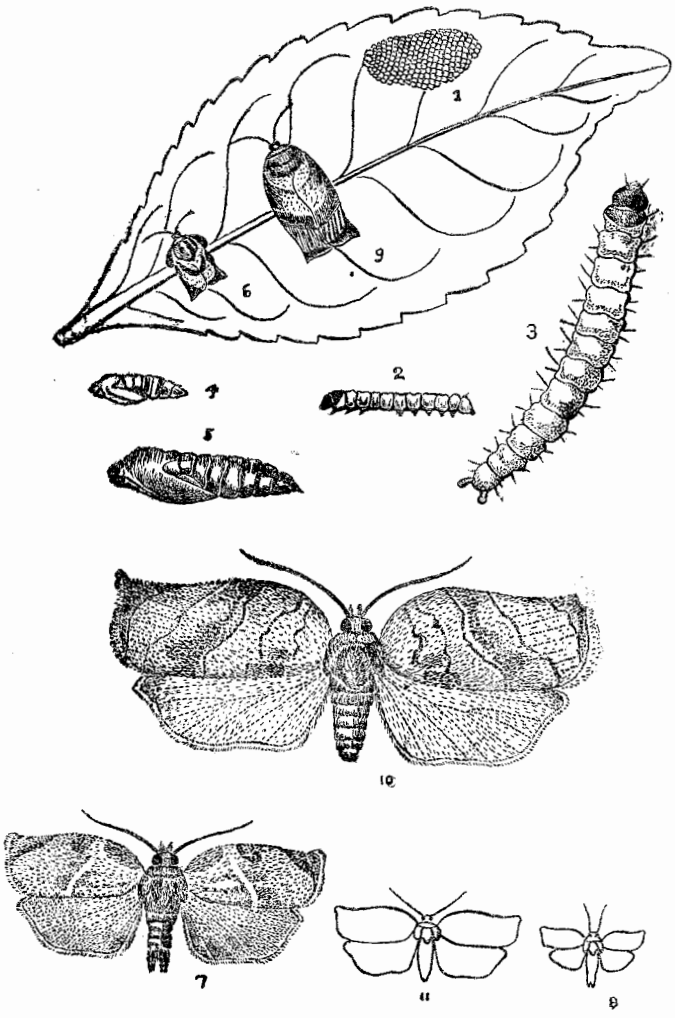


FIG. 291.—THE FLUSH WORM—1-10 STAGES.
(*Homona coffearia*, N.)

[*After Green and S.S.I.*]

FIG. 292.—THE COFFEE GRASSHOPPER.
(*Aularches miliaris*, L.)

[*From S.S.I.*]

(7) The red borer (*Zeuzera coffeæ* N., fig. 293).—This is the red caterpillar of a medium sized moth with spotted wings. Though found on coffee occasionally it is not a serious pest. The caterpillar bores into the stem. The usual remedies for stem boring larvæ will check the damage,

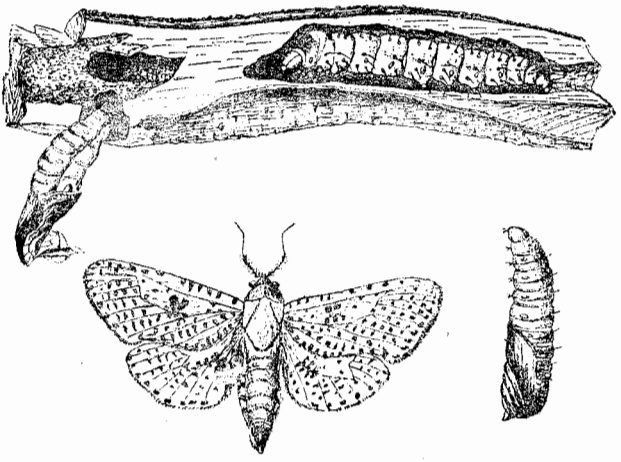


FIG. 293.—THE RED BORER OF COFFEE—STAGES. (*Zeuzera coffeoe*, N).

[*From I.M. Notes*]

TEA.

Of all the insect pests of tea, the tea mosquito (*Helopeltis*) ranks first, all others being of minor importance or rarely found as sporadic local pests. The scale insects, mealy bugs and some leaf caterpillars come next in rank.

THE TEA MOSQUITO—(*Helopeltis antonii*, S., *Fig.* 294).—This is an active slender insect belonging to the same group as the cholam earhead bug and the betel vine bug already noted ; and the life history and habits are quite similar to those of the latter. This bug on tea has a mixed red, black and white colour and it has a peculiar erect knobbed process on its back, which is quite characteristic of the insect. The damage done to tender shoots and foliage of tea is very characteristic ; due to numerous punctures made by the bug and the drainage of sap the tender parts curl up, fade and often dry up. Life history is similar to the betel vine bug. In the tea districts of India different measures are tried against this serious pest including cultural, mechanical and insecticidal methods with varying results. Of all measures, the catching of the adult bugs with nets, sticky winnows, etc., appears to be the most economical and feasible. In some places, a closely allied bug (*Disphinctus humeralis*, W.) is also found in company with the tea mosquito.

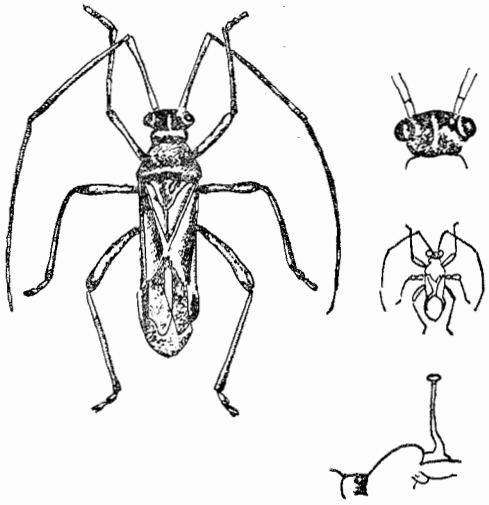


FIG. 294.—THE TEA MOSQUITO BUG.
(*Helopeltis antonii*, S.)
[*After Distant*]

Leaf caterpillars—Numerous caterpillars have been recorded as leaf eaters on tea. Chief of those are—

(1) the red slug (*Heterusia virescens*, B.)—The larva of a beautiful butterfly like bright metallic coloured moth: this sometimes appears as a sporadic local pest; fig. 295;

(2) the tea looper caterpillar (*Buzura suppressaria*, G.; fig. 296);

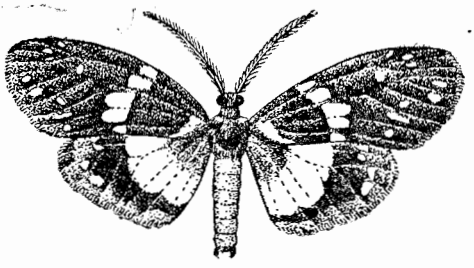


FIG. 295.—THE TEA HETERUSIA.
(*Heterusia virescens*, B.)
[*From S.S.I.*]

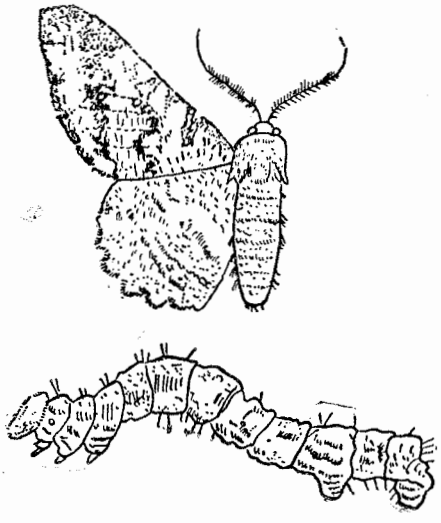


FIG. 296.—THE TEA LOOPER.
(*Buzura suppressaria*, G.)
[*From I.M. Notes*]

(3) the flush worm (*Homona coffearia*, N., fig. 291);

(4) a small leaf folder (*Laspeyresia leucostoma*, M.) found often with another leaf folder *Gracillaria theivora* in parts of Wynaad and Nilgiris on the first flush after clipping;

(5) two slug caterpillars (*Contheyla rotunda*, H., fig. 266, and *Thosea cervina*, M.);

(6) a hairy caterpillar (*Dasychira horsfieldi*, S.);

(7) bag worm moth (*Clania crameri*, fig. 32).

While mechanical methods can be employed in stray attacks, bad infestations might call for arsenical sprays.

Shot hole borers of different species (chiefly *Xyleborus fornicatus*, E., fig. 297) often attack tea twigs and stems and breed on the living plants. The stem borer longicorn (*Sthenias*) is sometimes noted.

Some scale insects (chiefly *Aspidiotus camellæ*, S., fig. 298, a pale grey oval egg like scale, *Hemichionaspis theæ*, G., fig. 81, *Saissetia hemisphericum*, T., and a recently noted form *Lecanium formicariae*. G.) are sometimes found covering the shoots and stems. These pests will easily submit to pruning and contact sprays.

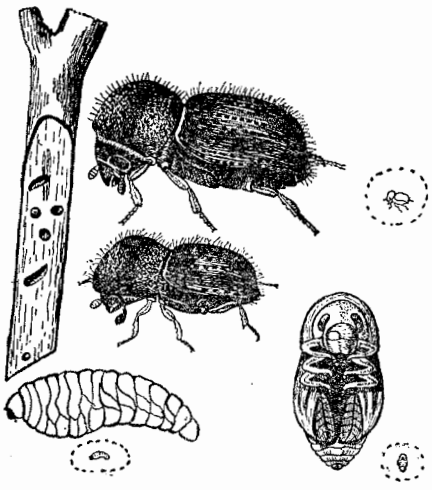


FIG. 297.—THE TEA SHOT HOLE BORER. (*Xyleborus fornicatus*, E.) [*From I.M. Notes*]

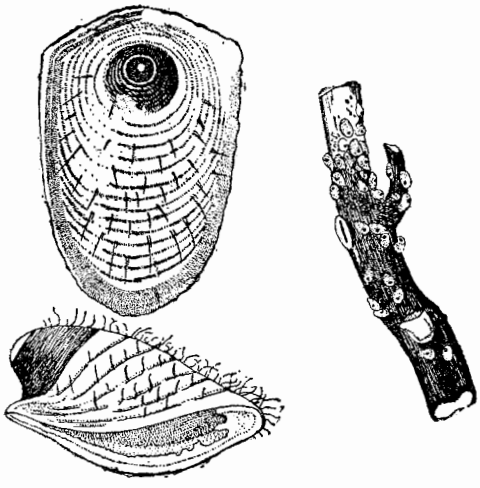


FIG. 298.—THE CAMELLIA SCALE OF TEA. (*Aspidiotus camelliæ*, S.) [*After Green*]

Occasionally the red caterpillar borer noted under coffee (*Zeuzera coffeæ*, N.) and another borer (*Indarbela theivora*, H.) are found on the plant stems. A species of thr ps (*Dendrothrips bispinosus*, B.) and the tea mites (*Phytopus carinatus* and *Tetranychus bioculatus*) may be regarded as pests of minor importance on tea (fig. 404). A leaf webber (*Ereboenis saturata*) has been recorded on tea in South India.

Cocoa.

In the Government Gardens, Kallar, Nilgiris, where this plant is tried, the pods were found very badly infested by a mealy bug (*Pseudococcus citri*, R., fig. 299). It is likely that the Cocoa thrips (*Selenothrips rubrocinctus*, G.) may gain access to the plant if it is planted on any large scale [fig. 97 (3)], since this thrips is already found on cashew in South India.

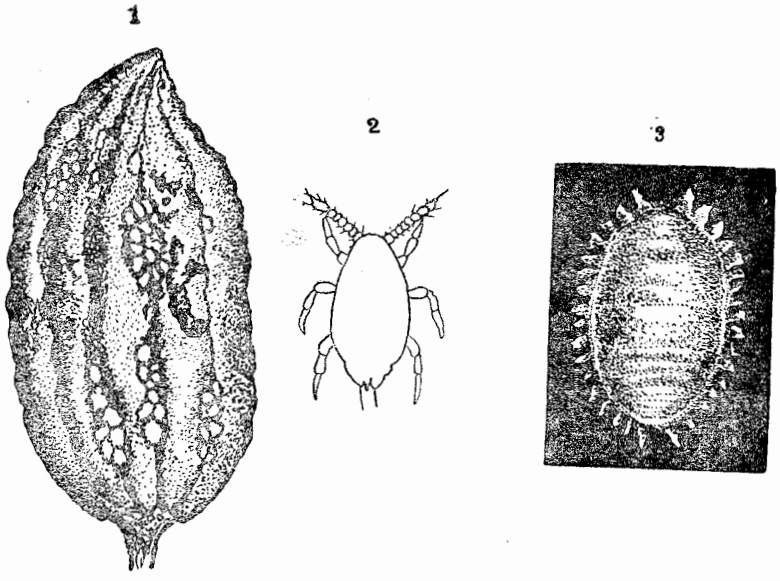


FIG. 299.—MEALY BUG ON COCOA.
[*Pseudococcus citri*, R.)
1 Bugs on cocoa pod. 2 & 3 Larva and bug enlarged.

Cinchona.

In the Cinchona plantations which are maintained on the hills under Government supervision, the only trouble with insects till now has been with cockchafer beetles, the underground grubs of which damage the seedlings seriously. Several species have been noted (chief being *Holotrichia repetita*, S., *Rhizotrogus rufus*, A.,

Serica nilgriensis, S., and *Popillia chlorion*, N.). The adults come to light in thousands during the summer; the whitish grubs can be hand-picked and destroyed or the seed beds irrigated with water mixed with crude oil emulsion, fig. 300.

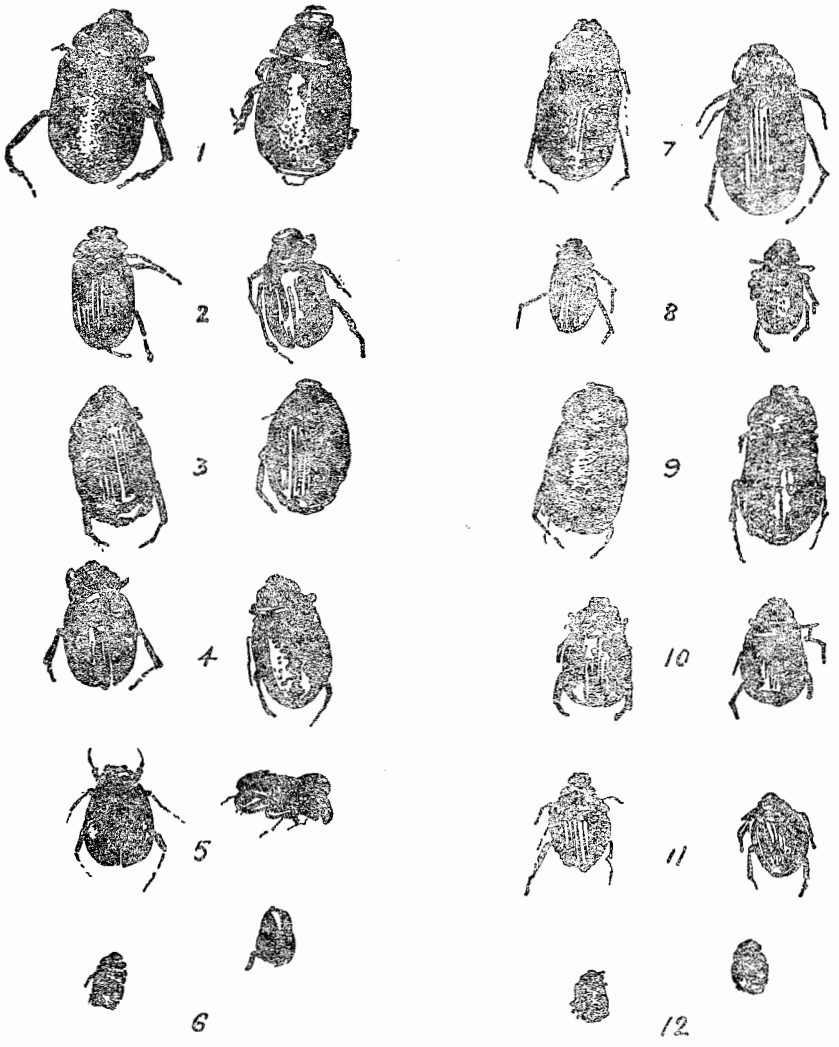


FIG. 300.—COCKCHAFERS IN CINCHONA GARDENS.

[*From Barber*]

Occasionally, an active leaf bug (*Disphinctus humeralis*, W.) is found on the tender foliage; this bug is closely allied to the tea mosquito and has the same habits. On the leaves of young plants are sometimes found one or two species of weevils (chiefly *Sympiezomias decipiens*, M.) which are, however, of minor importance.

Rubber.

This crop chiefly grown along the lower slopes of the Western Ghats is not found subject to any important insect pests. The mango stem borer beetle (*Batocera rufomaculata*, Dg.) has been noted on a few occasions doing some damage to the tree stems and branches. Occasionally minute brownish shot hole bark beetles (*Xyleborus biporus*, S.) and a small bark boring caterpillar like (*Aetherastis circulata*, M.) are sometimes found boring into bark and interfering with the flow of latex; it is doubtful whether these are real pests or only visitors to an already diseased tree. Scale insects are often found on the twigs and foliage (species like *Aspidiotus cyanophylli*, S., *Saissetia nigra*, N., etc.).

It must be admitted that further investigations have to be made on the crops of these South Indian Hill plantations to get more detailed ideas of these plantation pests and their economic status.

CHAPTER XVIII.

Pests of Garden Plants, Grasses, Fodder, Green Manure Crops and some important trees of the plains.

Garden and Flower Plants.

Our garden plants generally include flowering plants, ornamental shrubs and creepers, hedge plants, crotons, etc. Of these grown in the plains, very few are found severely subject to insect pests. Among the categories of insects which are generally found common to most of these are plant lice, white grubs, beetles of different kinds, scales, mealy bugs, thrips and leaf caterpillars and sometimes ants also.

Rose.

The important insect pests noted on the rose plant are—

(1) The leaf caterpillars, of which the commonest are the two red brown tussock caterpillars (*Euproctis fraterna*, M., and *Porthesia scintillans*, W.), the castor slug (*Latoia lepida*, C.), the castor semilooper (*Achœa janata*, L.) and the crab caterpillar (*Stauropus alternus*, W., fig. 137). Handpicking is easy in all these cases.

(2) The grape vine thrips (*Rhipiphorothrips cruentatus*, H., fig. 97-2) is sometimes serious causing the tender leaves to turn sickly and dry up; a dusting with dry tobacco will check this pest.

(3) A small reddish brown hard scale (*Aonidiella aurantii*, M., fig. 301) sometimes covers the tender shoots causing the latter to fade and dry. Prompt pruning of infested parts and if necessary a wash with a contact insecticide will control the pest. This is the citrus red scale noted before.

(4) Rose chafer beetles of different kinds (*Oxycetonia versicolor*, F., fig. 92, *Adoretus versutus*, H., etc., fig. 302) and the leaf cutter bees (chiefly *Megachile anthracina*, S.) sometimes cause some appreciable damage to the foliage. Light traps will check the former and a dusting of lead arsenate powder will check both.

(5) Plant lice sometimes attack the tender shoots (chief species—*Macrosiphum rosœformis*, D.). This will yield to the same treatment as adopted for thrips or scales.

The young cuttings occasionally suffer from the attacks of white ants and the stems now and then get attacked by the beetle (*Sthenias grisator*, girdler F., fig. 243).

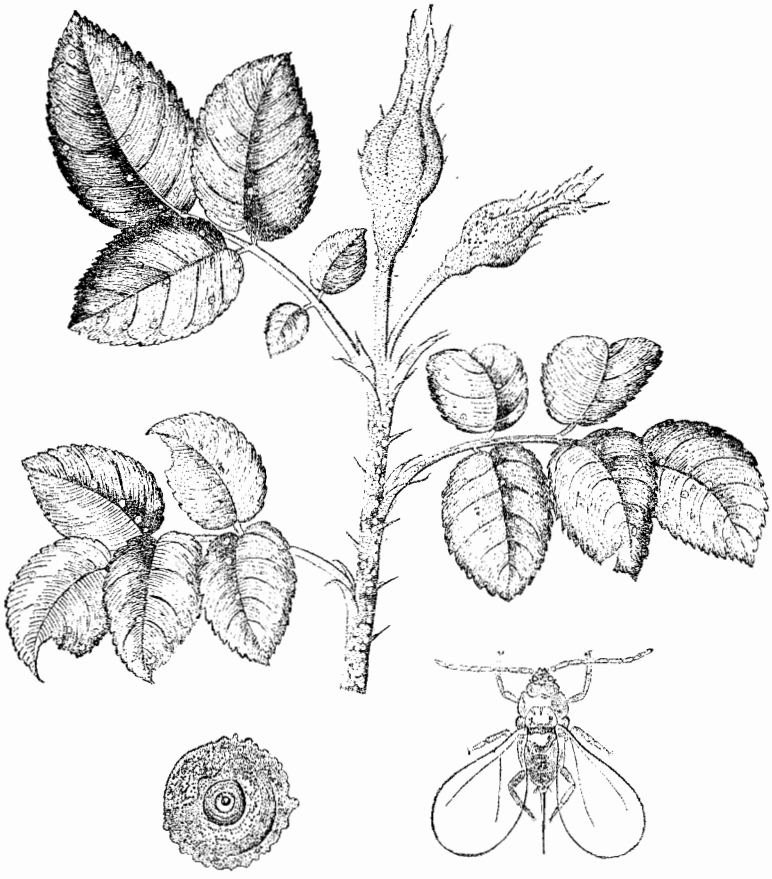


FIG. 301.—THE RED SCALE ON ROSE.
(*Aonidiella aurantii*, M.)
1 Infested shoot. 2 & 3 Female and male insects.

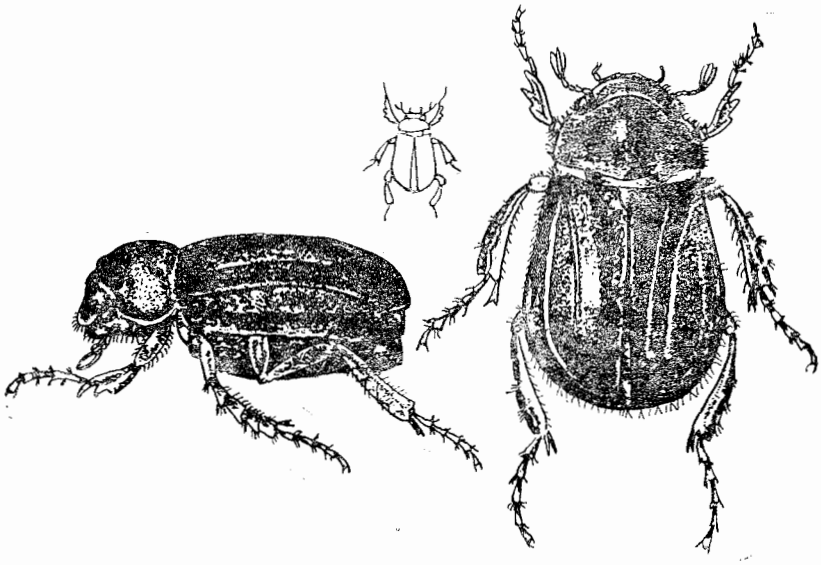


FIG. 302.—GARDEN COCKCHAFER.
(*Adoretus versutus*, H.) [*From I.M. Notes*]

Jasmine.

The pests of jasmine are mainly sucking insects. Of these, the jasmine bug, an active flattish oval stink bug (*Antestia cruciata*, F., fig. 303) is a specific pest of jasmines, though noted sometimes on coffee also; it causes serious damage in some flower gardens sucking up the tender shoots and buds preventing flower formation. This creature can be collected with nets or handpicked; in bad cases it can be killed by fumigating the plants with cyanogas under a small tent. The others include a small lace-wing bug [*Leptopharsa ayyari*, D., fig. 10 (6) p. 20], a pretty looking white mealy bug (*Phenacoccus ornatus*, G.), a mealy wing (*Dialeurodes vulgaris*, K.) a thrips (*Isoneurothrips orientalis*, B.) and the red scale of rose (*Aonidiella auranti*, M.). These suck up sap from the tender shoots and buds and allow the plants to fade. They can be checked by prompt pruning or spraying with contact washes. In some places the leaf rolling green caterpillar of a moth with transparent whitish wings (*Glyphodes unionalis*, F.) is occasionally met with; in this case, the leaf folds with the larvae should be collected and destroyed. Mites are sometimes bad on Jasmine.

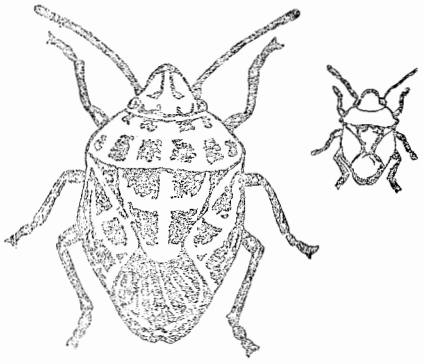


FIG. 303.—THE JASMINE STINK BUG.
(*Antestia cruciata*, F.)

[*Form S.S.I.*]

Chrysanthemum.

A slender caterpillar of a medium sized yellowish moth (*Lamprosema indicata*, F. fig. 304) is found doing damage to the tender foliage and flower heads of this plant in parts of Madurai and adjacent areas; it is found on sunnhemp and horsegram in some areas. A thrips (*Haplothrips ramakrishnæ*, K.), sometimes attacks the flowers. An aphid (*Macrosiphum sanborni*, G) is found on this plant.

Balsam.

On balsam plants grown in gardens the yam beetle (*Galerucida bicolor* H.) and a leaf feeding moth caterpillar (*Sylepta textalis*, L.) are found as minor pests.

Lilies and Oleander.

The only important insect found on garden lilies (*Crinum* spp.) in South India is the pretty white and red spotted lily caterpillar (*Polytela gloriosæ*, F., fig. 305) often met in numbers burrowing into the succulent tissues of the leaf; the caterpillar of a noctuid moth (*Brithis crini*, H.), is found with *Polytela* in parts of Cochin. The leaves with these gregarious larvae can be easily destroyed and the underground pupae dug up. The garden oleander is

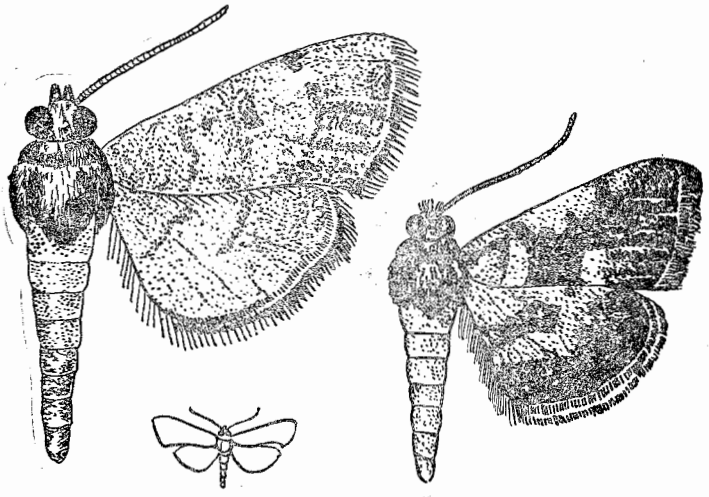


FIG. 304.—THE CHRYSANTHEMUM MOTH.
(*Lamprosema indicata*, F.) [*From S.S.I.*]

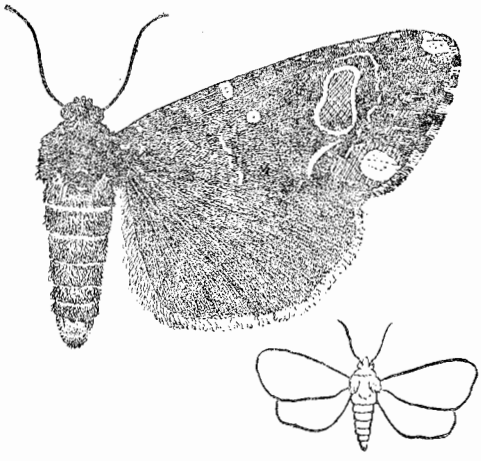


FIG. 305.—THE LILY MOTH.
(*Polytela gloriosæ*, F.)

[*From S.S.I.*]

commonly attacked by the larva of the common dark-spotted winged nymphalid butterfly (*Euploea core*, C.) and also by the stout-built long caterpillar of the oleander hawk moth (*Deilephila nerii*, L., fig. 91-2), a specific pest of this plant. These caterpillars can be easily handpicked.

SHOE FLOWERS, HOLY-HOCK, MIMUSOPS, SUN FLOWER, ETC.

Most of the insects found on the cotton plant attack shoe flower plants and other malvaceous garden shrubs also (spotted boll worms, leaf roller caterpillar, red and dusky bugs, blister beetles, scales, etc.); on sun-flower, the gram caterpillar (*Heliothis armigera*, F.)

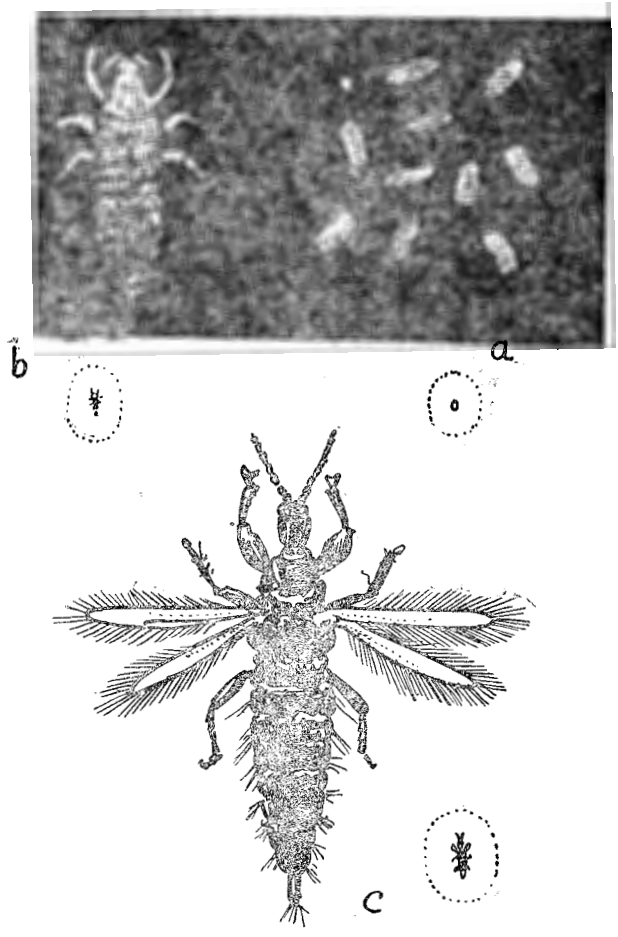


FIG. 306.—THE MIMUSOPS THRIPS.
(*Arrhenothrips ramakrishnæ*, H.)
a eggs. *b* nymph. *c* adult.

is occasionally found feeding on the leaves and flower heads; on Makutam (*Mimusops*) a flower plant which often grows into a large and beautiful shade tree gets its foliage and shoots badly galled in some parts of South India especially Coimbatore and Tiruchirappalli, by a black thrips (*Arrhenothrips ramakrishnæ*, H., fig. 306); all the stages of the insect are found inside these galled leaves which are very conspicuous, fig. 306. The black scale (*Saissetia nigra*) is also a common pest of some of these garden plants.

On Parijath (*Nyctanthus arbortristis*) a few caterpillars have been noted to attack the shoots, the foliage and the flower buds; chief of these are a stout spiny and irritating lasiocampid caterpillar (*Metanastria hyrtaca*, C., fig. 307) and a bud caterpillar (a microlepidopterous moth) which checks flower formation. The stout caterpillar of a hawk moth (*Psilogramma menephron* Cr.) is sometimes found on this plant. The garden shrub Tabernimontana with dark green leaves giving white single and double flowers, is subject to some leaf caterpillars (chiefly *Glyphodes glauculalis*, G.) which can be checked by prompt handpicking.

Garden Crotons, Artemesias, etc.

Scales and mealy bugs are the chief pests of these plants. The former include the black scale (*Saissetia nigra*, N., fig. 308), the soft scale (*Lecanium depressum*, C.); two common mealy bugs (*Icerya ægyptiaca*, D. and *Ferrisina virgata*, C.) attack crotons of all kinds often badly, figs. 82 and 218. A hard scale (*Parlatoria pergandii*, C.) is found on crotons on the hills. Another active species (*Monophlebus phyllanthi*, G.) also occurs in some places. Next to these, we find two species of thrips—one a notorious widely distributed hot house species (*Heliothrips homorrhoidalis*, B., fig. 97-5) and another (*Ayyaria chaetophora*, K.) which has been noted on lablab and other legumes also. In some gardens, the stem girdler longicorn beetle (*Sthenias*) attacks the stems of crotons also. The most important pest of "Tulsi" (*Ocimum*) is the small dark lacewing bug (*Monanthia globulifera*, W., fig. 309). This bug is also found on *Carthamus*, *Coleus*, *Mentha*, etc. It is often found in colonies in all stages, on the tender foliage and shoots; badly infested plants show the foliage turned completely brown and gradually drying up. Another insect occasionally noted is a scale insect (*Ceroplastodes cajani*, M,) which is also found on redgram, lablab and zizyphus; colonies of these waxy oval insects cover the shoots and suck up the sap, fig, 310. For both these pests, pruning and tobacco wash can be resorted to. The *Artemesia* plants are subject to another tingid pest—*Leptopharsa ayyari* D—noted on jasmine also.

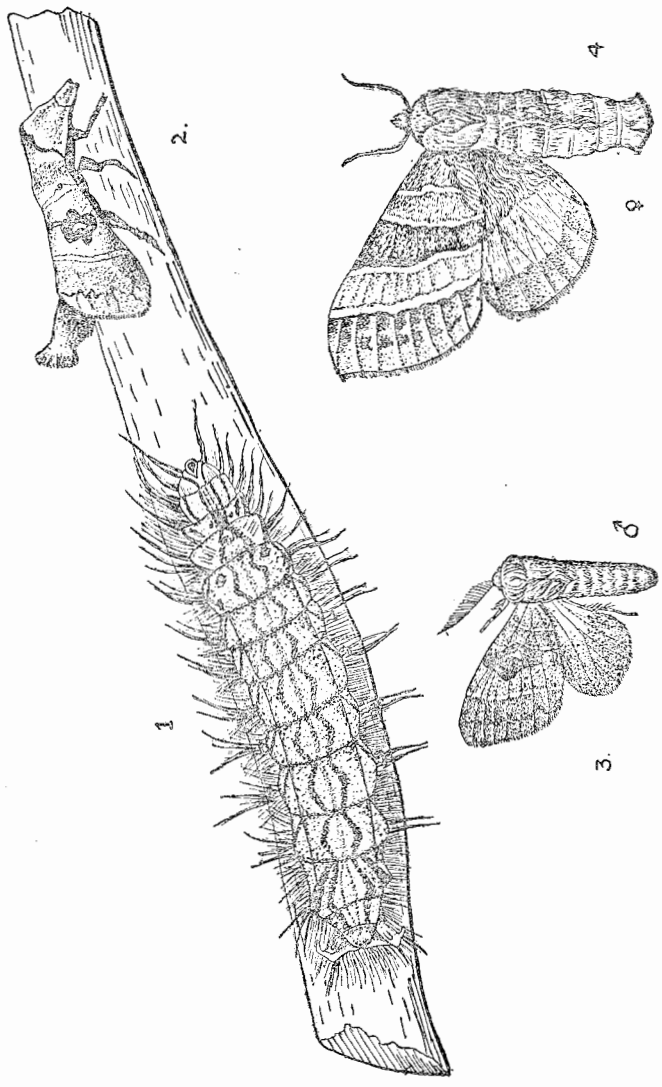


FIG. 307.—THE PARIJATH HAIRY CATERPILLAR.

(*Metanastria hyrtaca*, C.)

1 & 2 Caterpillar and moth on plant. 3 & 4 Male and female.

[*From S.S.F.*]

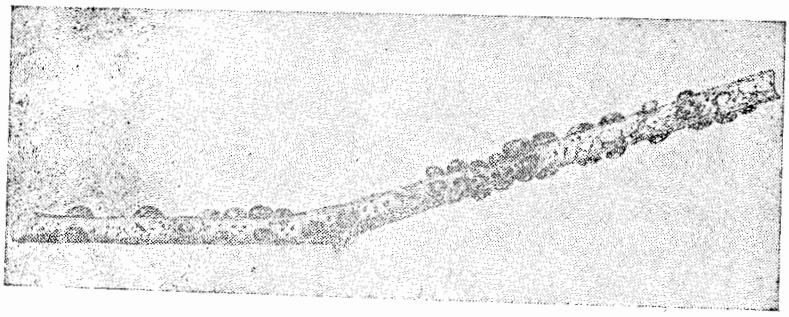


FIG. 308.—THE BLACK SCALE.
(*Saissetia nigra*, N.) [*From S.S,I.*]

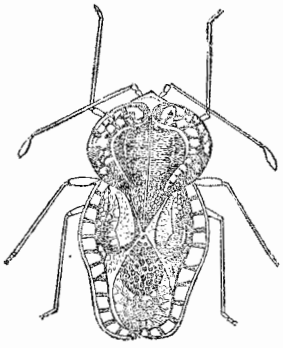


FIG. 309.—THE TULSI LACE-WING BUG.
(*Monanthia globulifera*, W.) [*After distant.*]

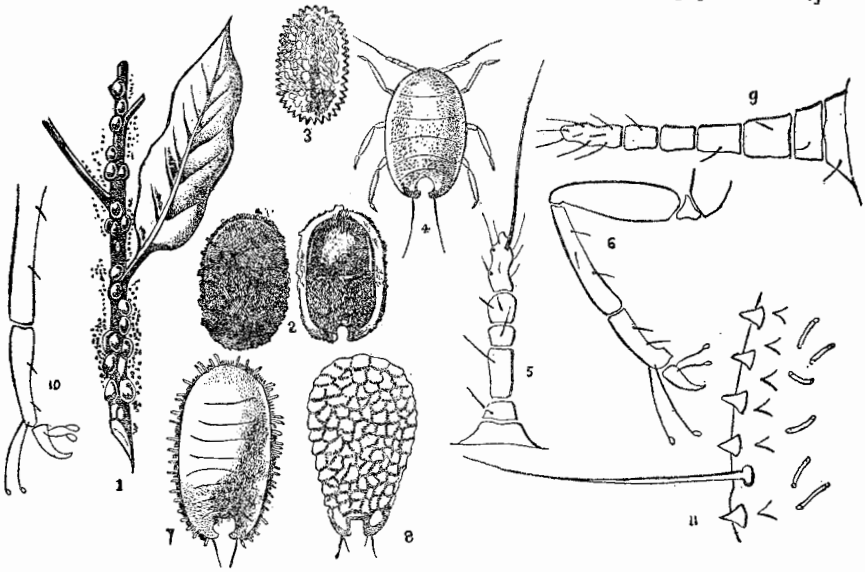


FIG. 310.—THE WAXY SCALE OF TULSI—STAGES, ETC.
(*Ceroplastodes cajani*, M.) [*From I. M. Notes.*]

Bignonia and Millingtonia.

These garden plants are occasionally subject to the attentions of the caterpillar of the well-known teak leaf pest (*Hybloea puera*, G, fig. 328). The leaf folds with the caterpillars may be clipped off or a stomach insecticide sprayed in bad attacks.

Cycads, Ferns, etc.

Some of these ornamental palms, especially grown in ferneries and glass houses, are found infested with scales of different kinds chiefly *Chionaspis dilatata*, G., a whitish hard scale found on the foliage, the same noted on areca palm (fig. 270).

Champaka (*Michelia champaka*).

It is well known that the flowers of this tree found growing chiefly along the rain-fed areas of the West Coast are in great demand everywhere. The foliage of this tree, especially in young trees, has been recently found by the author to be subject to the attacks of a caterpillar, the larva of a beautiful black and green-marked swallow tailed butterfly (*Papilio agamemnon*, L.) in Malabar ; numbers of them appear during the rainy season and defoliate the branches.

Lotus.

This aquatic climber the flowers of which are held in very high estimation among flowers is sometimes found subject to the attentions of a few insects. Those noted so far include three leaf feeding caterpillars—the tobacco *Prodenia*, an aquatic caterpillar (*Nymphula* sp.) similar to the paddy caseworm in habits and a hairy caterpillar (*Semyra conspersa*, M.), a species of thrips evidently new (*Scirtothrips*) and the plant lice species (*Siphocoryne nymphae*, L.), known as the water lily aphid. Of these the hairy caterpillar does some appreciable harm at times, especially in the Ceded Districts and N. Circars.

Jatropa.

Garden jatropa is subject to mealy bugs (chiefly *Ferrisina virgata*, C.) and scales (chiefly *Hemilecanium imbricans*, N., fig. 311) and sometimes the nim scale *Pulvinaria maxima*, G., fig. 324).

On *Ixora* and *Echitis* a scale insect (*Aspidiotus trilobitiformis*, G.) has been found on the leaves and shoots in the Northern Circars and Malabar ; on the latter a mealy wing (*Dialeurodes*) is also found.

Garden Creepers and Climbers.

Species of Ipomea, Bougainvillea, etc., very rarely suffer from insect pests of any importance. The stem girdler beetle (*Sthenias*) is however found to do some damage to these vines during certain

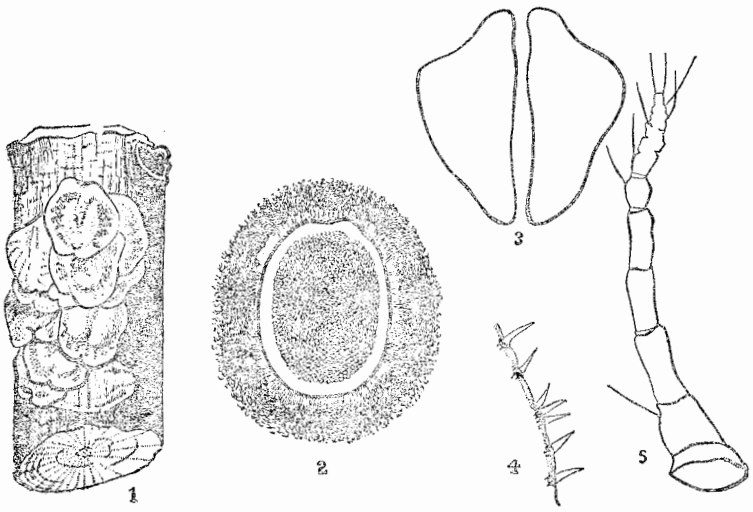


FIG. 311.—LARGE SCALE ON JATROPA.
(*Hemilecanium imbricans*, G.)
1 Infected branch. 2 Scale and parts.
[*After green.*]

seasons. On some species of Ipomea, a stem boring brownish caterpillar (*Omphisa anastomosalis*, D.) is sometimes found; this attacks sweet potato also occasionally (fig. 199).

Several garden plants on the hills suffer during certain seasons from the attack of *thrips* of different kinds and ants (like *Dorylus*); especially it is so when the season is warm.

Insects of Grasses, Fodder, Green Manure Crops, etc.

Grasses (*Guinea grass, etc.*).—The insects which chiefly attack grasses of different kinds are the leaf caterpillars of different species, chiefly the yellow hairy caterpillar of paddy (*Psalis securis*, H., fig. 104-1), the cutworms of different kinds, fig. 83, (*Spodoptera mauritia*, B., *Cirphis albistigma*, M., *and C. loreyi*, D.) and others (*Pelamia frugalis*, F., *Psara phacopteralis*, G., and *Hymenia fascialis*, G.) which during certain seasons become regular plagues in grass lands and cause severe havoc in some pasture areas. The climbing cutworm of paddy (*Cirphis albistigma*) causes severe damage in cattle farms and grass areas during certain seasons all over the province. In some grass areas where the plants are in flower, the rice bug (*Leptocorisa acuta*, T.) is sometimes found sucking these flower heads and succulent seeds. Grasses in some hill tracts are sometimes found infested with some hard scales (chiefly *Chionaspis herbae*, G., and *C. graminis*, G.). Stacked fodder of ragi, cholam, etc., sometimes suffer from the attack of a moth caterpillar (*Simplicia robustalis*, G., fig. 312).

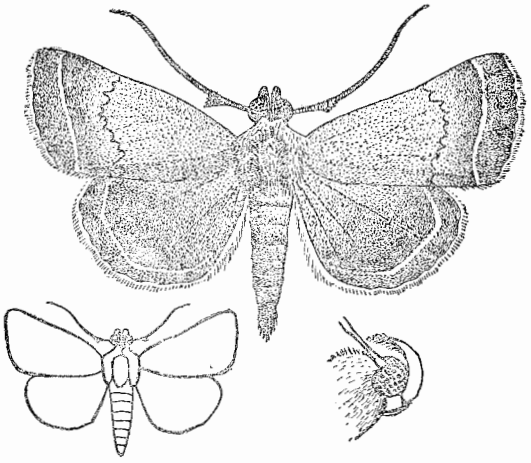


FIG. 312.—DRY GRASS MOTH.
(*Simplicia robustalis*, G.)

[*From S.S.I.*]

Lucerne (*Medicago sativa.*).—This fodder which is cultivated only in small areas, chiefly in some Government farms, is generally found subject to the attacks of the onion caterpillar (*Laphygma exigua*, H.) and the red pumpkin beetle (*Aulacophora foveicollis*, F.) At times thrips and aphids are also noted though not seriously.

Bamboo (*Dendrocalamus, etc.*).—Bamboo clumps in fields and gardens occasionally show some insect damage, though none of a serious nature is generally found. The following bamboo insects

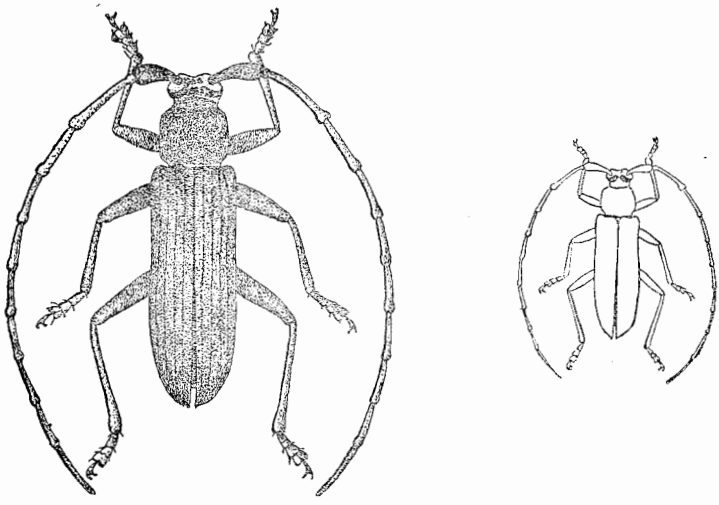


FIG. 313.—BAMBOO BORER BEETLE.
(*Stromatium barbatum*, F.)

[*From S.S.I.*]

have been noted in South India. *Leaf defoliators.*—Several bamboo defoliating caterpillars have been noted in different parts of India by Mathur. Those found in South India include the butterflies.—*Lethe drypetis* H. *Telicota augias L* and *T. bambusae* and the moths; *Pyrausta coelesalis* W. and *Calamochrous pentasarsis* M.) A stem boring grey longicorn beetle (*Stromatium barbatum*, F., fig. 313) found breeding in the stem in the Ceded Districts, and the shoots of tender bamboo have been found by the author burrowed by a chalcid grub—possibly a phytophagous form (*Euryotoma chrysothrix* W.) in the Walayar forests. Fruit flies (*Stictaspis cratitina*) have been reared from the tender bamboo shoots in Kallar forests. A shining black weevil (*Conarthrus jansoni*, W.) is often

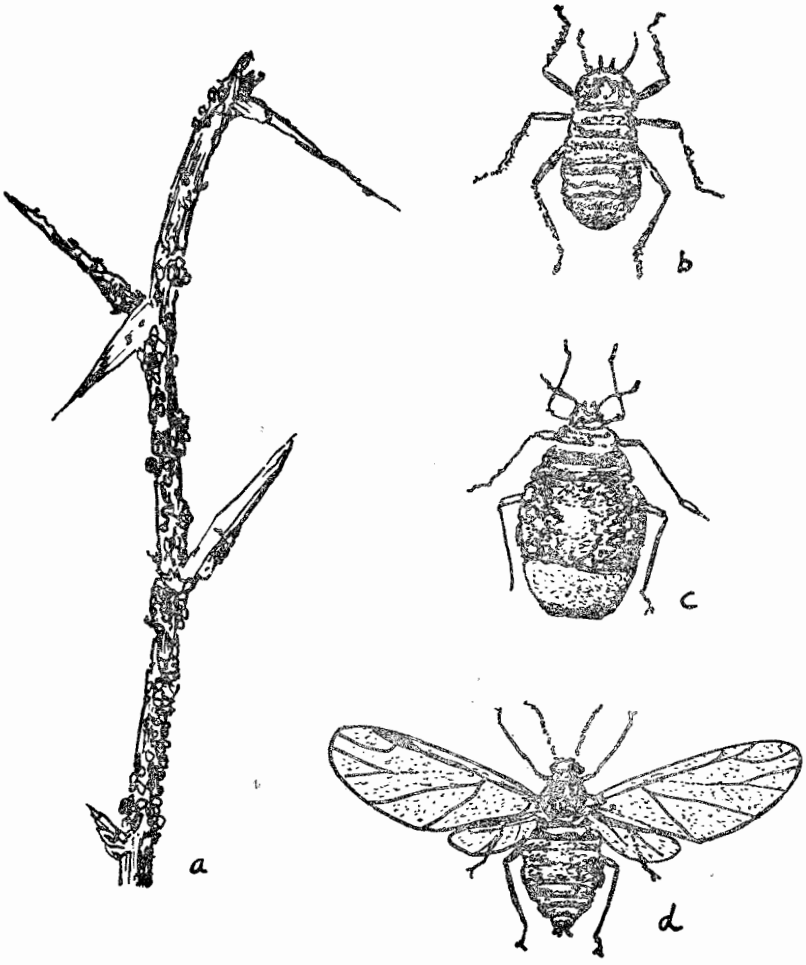


FIG. 314.—WOOLY APHIS ON BAMBOO.
(*Trichoregama insularis*, D.)
a Attacked shoot. *b-d* Wingless and winge forms.

found boring into dry bamboo frame work with species of shot hole borers of the genus (*Dinoderus* in parts of the West Coast. All the others are sucking insects which include a wooly aphid (*Trichoregama insularis* D. fig. 314) colonies of which cover the tender shoot and leaves, scales (especially *Asterolecanium longum*, G. and *Chionaspis elongata*, G.) and a mealy bug (*Pseudococcus detorquens*, G.) found sometimes covering the tender shoots and nodes. Occasionally an active pale grey leaf hopper bug (*Purohita nigirpes* D.) is found to breed in hundreds between the leaf sheaths and the tender stem secreting a good deal of waxy matter, like the sugarcane leaf hopper (*Pyrilla*). The stink bug (*Ochrophara montana*) often appears in swarms when the bamboo flowers in some parts along the West Coast area.

Agathi and Daincha (*Sesbania* spp.)—The insects affecting these two plants are practically the same. Agathi which is utilized in different ways such as fodder, standard for betel vines and sometimes even as vegetable in households, is attacked by a few important pests. These include—

(1) A stout white cylindrical borer caterpillar, the larva of a big white and brown spotted leopard moth (*Azygophleps scalaris*, F., fig. 315). It is a fairly serious pest and all stems attacked are generally killed. Numerous eggs are laid on the plant in groups and the larvae find their way into the stem. A full grown caterpillar measures about three inches, with the body pale whitish and the head and thorax of a brownish colour. It changes into an elongate reddish brown pupa inside the infested stem itself; the pupa has transverse rings of small hooked spines which help it to move up and down the gallery. This insect is also found on Daincha. The insect though not very common is a serious pest. Control measures are mainly preventive being a borer; in young plants, however, some relief may be got by carefully operating the stem and removing the borer. In big stems borer solutions may be injected as for fruit tree borers.

(2) The tobacco caterpillar (*Prodenia litura*, F., fig. 281) is sometimes very bad in the nurseries of agathi in betel vine plantations; sometimes the creature defoliates all plants in a field in one night. In betel vine gardens such areas may be flooded to drown or bring up the hiding caterpillars; some contact insecticide may also be mixed with the water in such cases. For other remedies see under Tobacco.

(3) The agathi weevil (*Alcidodes bubo*, F., fig 316).—This is a specific pest of the agathi plant; it is a small red and white marked beetle with a prominen curved snout characteristic of weevils. The weevil and its grub breed in the top shoots of growing agathi and often cause serious damage to the shoots. The yellowish white boring grubs cause gall-like swellings at the shoots. It is very common in all areas and occasionally bad in South Arcot,

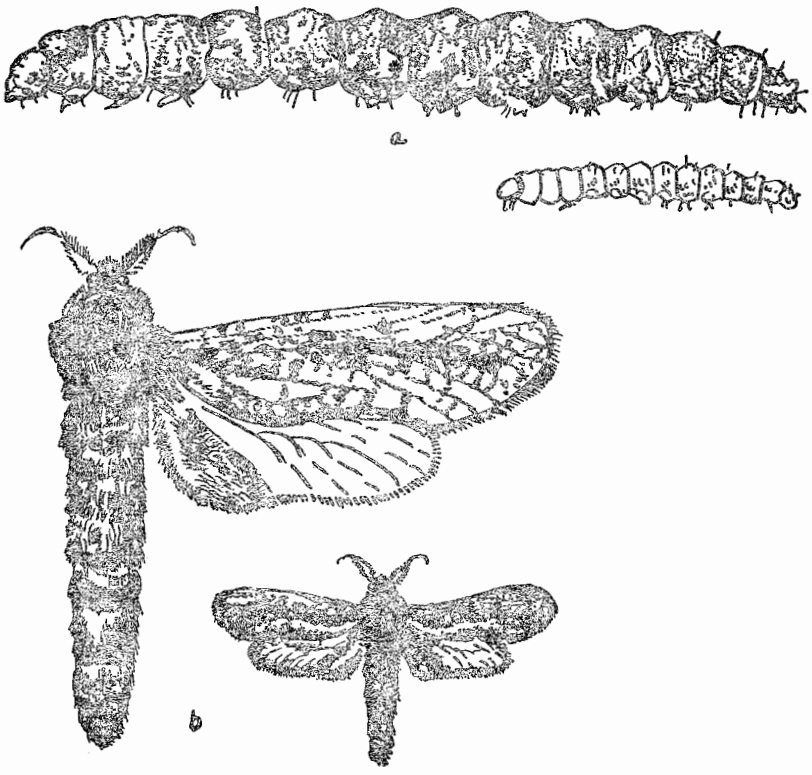
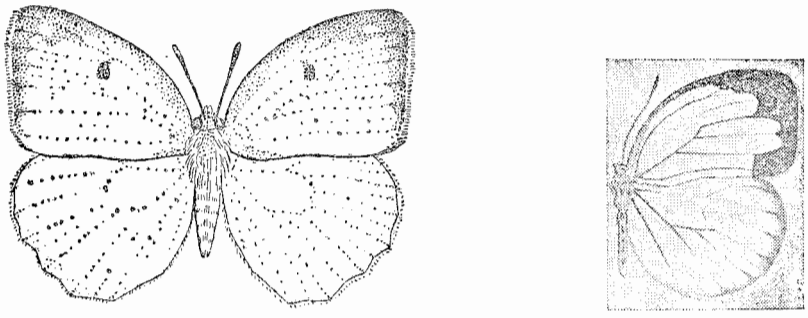


FIG 315.—THE AGATHI STEM BORER—MOTH AND CATERPILLAR.
(*Azygophleps scalaris*, F.)
[*From I.E.'s Report* 1917]

FIG. 316.—THE AGATHI WEEVIL.
(*Alcidodes bubo*, F.)
[*From S.S.I.*]

Ramanathapuram, Madurai and Coimbatore. It is not so injurious to grown up plants. It is also found on cluster beans and indigo. The best method of control is to clip attacked top shoots and collect the beetles. In bad cases a top dressing of some arsenate powder can be applied. Recent trials indicate that D.D.T. both in the form of dust and spray act satisfactorily in checking the pest. The green gram weevil (*Pachytychius* fig. 143) is found on Daincha often causing harm to the stem.

(4) Other leaf eating caterpillars include those of (*Grammodes stolida*, F., *Laphygma exigua*, H., fig. 83-III, *Pericyma glaucinans*, G. *Hyposidra successaria*, W and *Striglina scitaria*) and two butterfly larvae (*Terias hecabe*, L., and *Catopsilia pyranthe*. L. fig. 317).—Recently the caterpillar of the geometrid moth *Semiothisa pervolgata*, W. has been noted as a Daincha defoliator in Coimbatore. Occasionally some of these cause some appreciable harm and in valuable plots spraying or dusting with arsenicals may be found necessary, in addition to preventive measures like handpicking and collection and destruction of the adults in the case of the butterflies. When a fodder crop is attacked spraying with arsenicals should not be resorted to as far as possible, except with the necessary precautions.



1 2

FIG. 317.—AGATHI BUTTERFLIES.
1 *Catopsilia pyranthe*, L.
2 *Terias hecabe*, L.

[*From S.S.I.*]

(5) Seed wasp (*Bruchophagus mellipes*, G.).—The seed capsules, especially of Daincha, are sometimes attacked by the grub of this wasp. The adult is a small shining black chalcid wasp, a very rare example of a wasp grub feeding on plant tissue, the majority of the family being parasites on other insects.

(6) Some shoot bugs (chiefly the lablab bug *Coptosoma cribraria*, F.) and a black stink bug (*Brachyplatis vahlii*, F.) are usually found in numbers on the tender, shoots ; very rarely are they found doing any serious harm.

Kolingi (*Tephrosia purpurea*).—This green manure plant is commonly found subject to a pod borer caterpillar (*Dactylethra candida*, St.) which changes the seed pods into swollen galls ; it is the larva of a small brown moth and is fairly common in Tirunelveli and in the Tanjore delta. The arecanut beetle (*Araecerus*) is sometimes found on kolingi pods.

Murukkam (*Erythrina* sp.).—Similar to agathi, this plant is grown as a standard for betelvine along the West Coast and also for pepper vines in that tract. Though a few insects are often found in the plant they are very rarely serious. These include—

(1) A shoot and capsule borer (*Terastia metuculosalis*, G. Fig. 318).—The larva of this grey brown moth bores into the shoots and seed capsules and causes some injury. (2) Another leaf-folding caterpillar (*Agathodes ostentalis*, H.), the larva of a beautiful olive brown moth and the tussock moth caterpillar (*Notolopus* fig. 19) are occasionally found on the foliage. They are of minor importance only. (3) Shoot bug (*Cyclopelta siccifolia*, W. Fig. 319). This is a blackish stink bug commonly found on this plant in the West coast area. Occasionally this insect is found in thousands on this tree and on Pongamia trees though no serious injury is noted (fig. 319). (4) The pod bug (*Anoplocnemis phasiana*, F.), a large dark brown form with curious large hind legs is sometimes found on *Erythrina*; it has been noted before under Cowpea (fig. 147). (5) The stem girdler beetle noted under grape vine, crotons, etc. (*Sthenias grisator*, F.), has been noted damaging the plant in Coorg (fig. 243). (6) A small brownish spiny beetle (*Platypria echidna*, G.), is occasionally found as a leaf eater but is only a minor pest. (7) The green weevil (*Myllocerus viridanus*) is noted as a minor pest in Travancore. (8) In the submontane areas along the West Coast the tree is often subject to the attacks of the stem boring hepialid caterpillar, a stout caterpillar of a large moth (*Phassus malabaricus*, M. fig. 320). This insect is sometimes a very bad pest of the tree *Gamelina arborea* in parts of Malabar.

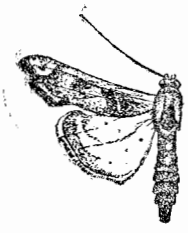


FIG. 318.—ERYTHRINA BORER MOTH. (*Terastia meticulosalis*, G.) [*From S.S.I.*]

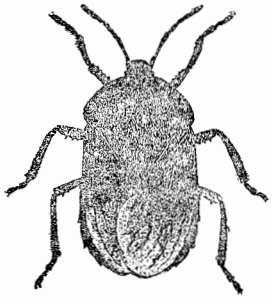


FIG. 319.—ERYTHRINA STING BUG. (*Cyclopelta siccifolia*. W. [*From S.S.I.*]

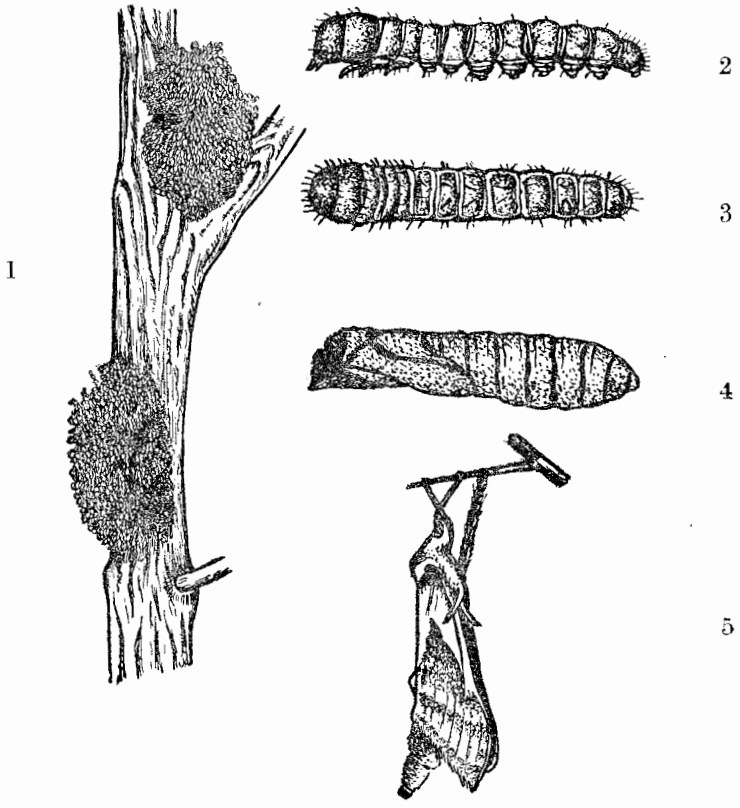


FIG. 320.—THE ROOT BORING PHASSUS.
(*Phassus malabaricus*, M.)
1. Attacked stem. 2 to 5 stages of insect.
[5. *After Lefroy*]

Erukkam (*Calotropis gigantea*).—The foliage of this plant is largely used as green manure in wet lands and it is also grown in gardens. Though a few insects have been noted on it the plant does not appear to suffer from any of these in any appreciable manner. The insects found are—

(1) Leaf caterpillars of butterflies (chiefly the Calotropis butterfly *Danais chrysippus*, L.).

(2) The stem weevil—a dirty grey beetle (*Paramecops farinosa*, W.); the grub of this creature burrows into the stem and shoots, fig. 321.

(3) A medium sized pale grey longicorn beetle (***Monohammus nivosus***, W.); the larva is a stem borer.

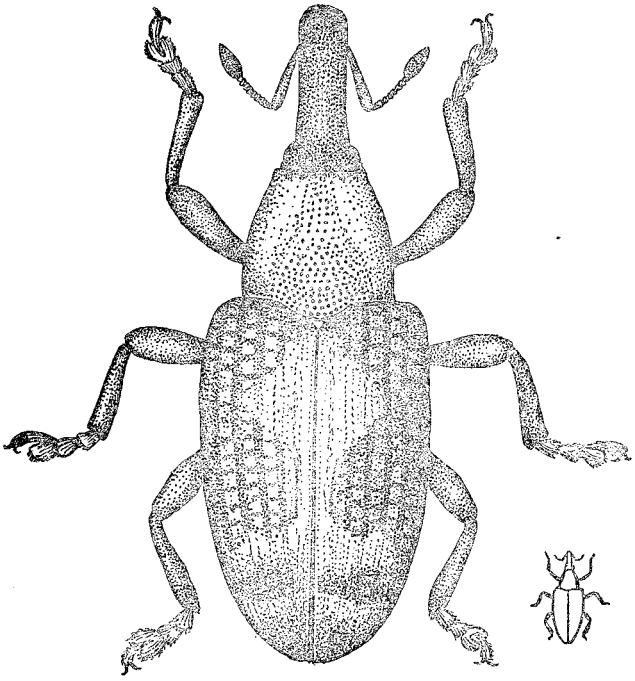


FIG. 321.—THE CALOTROPIS WEEVIL.
(*Paramecops farinosa*, W.)

[*From S.S.I.*]

(4) The calotropis grasshopper (*Poecilocerus pictus*, F.), an insect feeding chiefly on this plant; it has a graceful coloring, fig. 322.

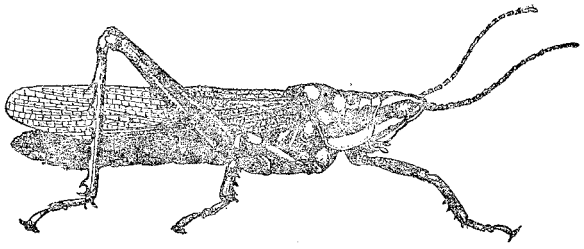


FIG. 322.—CALOTROPIS GRASSHOPPER.
(*Poecilocerus pictus* F.)

[*From S.S.I.*]

(5) A green striped leaf hopper bug (*Eurybrachis tomentosa*, F.) which is also found sometimes on cotton, *Hibiscus*, etc., fig. 323.

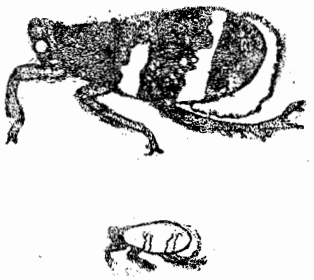


FIG. 323.—CALOTROPIS LEAFHOPPER BUG.
(*Eurybrachis tomentosa*, F.)

[*From S.S.I.*]

(6) The calotropis fruit fly (*Leptoxyda longistylus*, W.), a specific pest breeding inside the fruits of this plant only.

(7) Plant lice (*Aphis nerii*, F.), a yellow colored small insect often found in thousands on the leaves.

Many of the above insects are almost exclusively *Calotropis* feeders and are not usually found on other plants.

PESTS OF SOME IMPORTANT TREES.

Nim (*Azadirachta indica*).—The specific pest of this well-known tree, grown in gardens and roadsides and considered to have medicinal properties, especially in parts of Coimbatore, Ceded districts, etc., is the nim mealy scale (*Pulvinaria maxima*, G., fig. 324). Though occasionally noted on cotton, garden jatropa, etc., it is particularly bad on the nim tree. During certain seasons, trees are very badly infested by this pest and all its stages; the leathery brown females, the small white male puparia and the long white ovisacs of the female are found in profusion on infested trees, and the soil below the infested tree is wet with the honey dew thrown out by millions of these insects. The best remedy is to promptly prune all first infested shoots and burn them and, if possible give a contact wash to the trees. Another insect occasionally found on the young shoots and believed to cause the drying up of the distal shoots is the tea mosquito (*Helopeltis antonii*, S. fig. 294). The bugs should be collected whenever found. Whether this bug is the real cause of the drying up of the distal shoots—a common sight in many places—and if so, whether it causes any virus disease to the shoots are points to be further investigated. The fruits of this and allied species of nim are bored by the anthribid beetle (*Araecerus fasciculatus*) noted under areca (fig. 271).

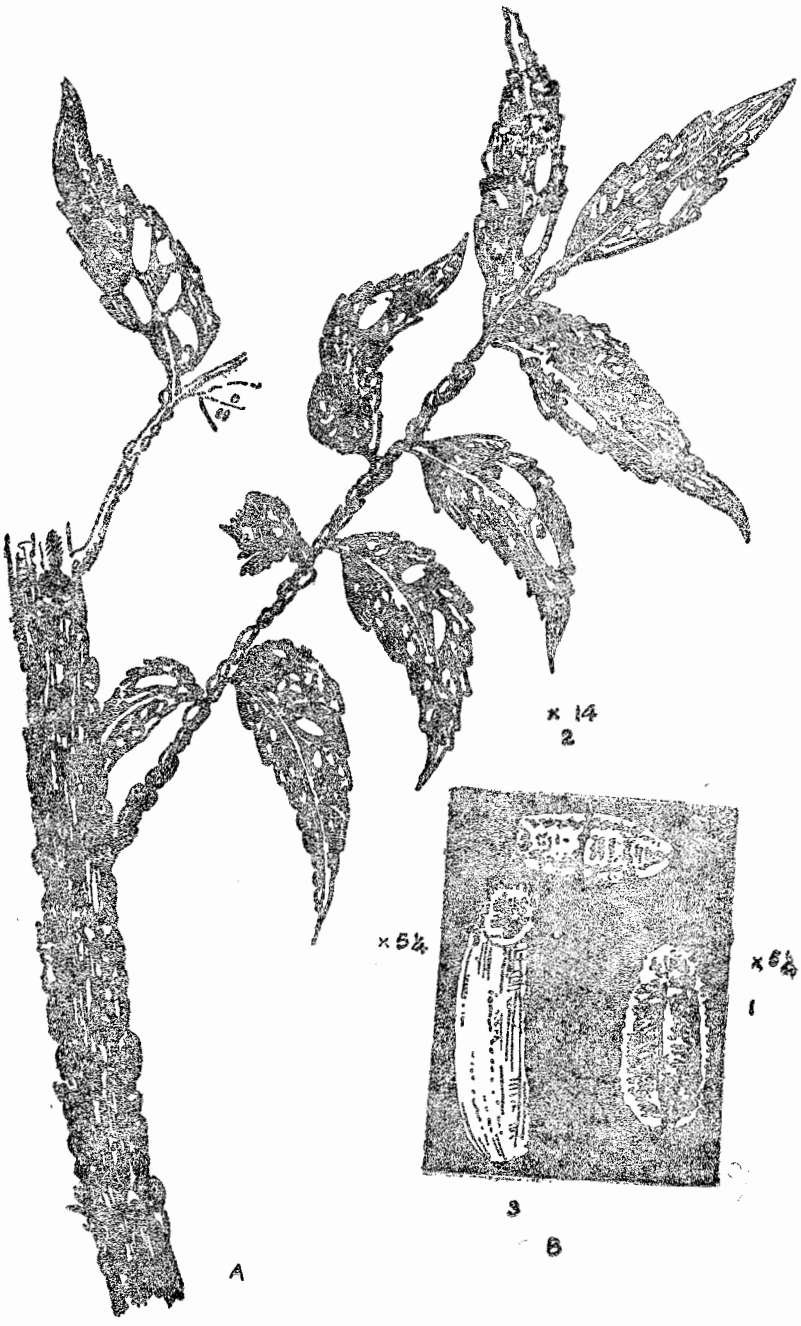


FIG. 324.—THE NIM MEALY SCALE.
(*Pulvinaria maxima*, G.)

A. Attacked branch. B. Stages of scale.

Babul (*Acacia arabica*).—Similar to nim, this tree has a specific scale pest of its own (*Anomalococcus indicus*, G.) a small dome shaped oval insect having a dirty brown color. The different stages of this creature are found in swarms on the babul branches and stems and in many cases a predatory moth caterpillar (*Eublemma scitula*, R. fig. 70) is also found among the scales; the pupal cases of the predator are very conspicuous on infested trees, fig. 325. Swarms of ants also help in distributing the scale pest from tree to tree. Others include two long hairy and spiny moth caterpillars (*Taragama siva*, *L.*, and *Metanastria hyrtaca*, C., fig. 307) which feed on the leaves and scrape the bark. The adult of the latter is a stout built chocolate brown moth. A small hairy caterpillar, the larva of a small yellowish moth (*Euproctis lunata*, W.) has been found as a sporadic pest completely defoliating babul trees in certain years in parts of the Northern Circars. Sometimes bagworms of different species are also found as minor leaf feeders.

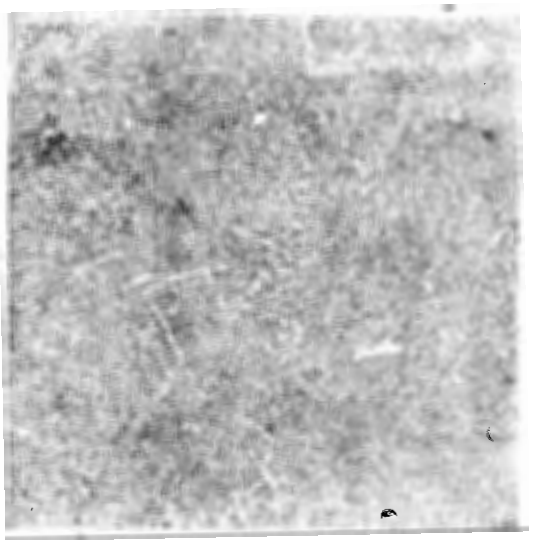


FIG. 325.—COCOONS OF SCALE PREDATOR MOTH ON BABUL (*Eublemma scitula*, R.)

Pungam (*Pongamia glabra*).—This tree, which is a good avenue tree and the leaves of which are often used as green manure is subject to sporadic pests only during certain seasons. These include the leaf folding caterpillar of a pale brown skipper butterfly (*Parata alexis*, F.), which sometimes completely defoliates the tree and the Erythrina and Lablab bugs (*Cyclopelta siccifolia*, W., and *Coptosoma cribraria*, F.) which often cover the whole tree in swarms The leaves and buds of this tree are commonly subject to the attacks of a gall fly (*Aspondylia pongamiae*, F.) almost everywher

The small maggot of this mosquito like fly causes irritation inside the buds and induces gall-formation. The galled fruits turn small and roundish unlike the normal ones which are almond shaped. The pods are sometimes bored by caterpillars (*Lamonia* sp.), but this is rare ; occasionally the curious looking caterpillar of a blue butterfly (*Curetis thetis*) is found on the leaves.

Portia (*Thespesia populnea*).—This tree is chiefly subject to scale pests. Of these, one is a specific one—the Portia mealy scale (*Pulvinaria thespesiae*, G.) exactly resembling the nim mealy scale and causing the same kind of injury to the tree and found in parts of Godavari and Tanjore ; the other is the common black scale (*Saissetia nigra*, N.) noted under cotton, crotons, etc. This black scale is sometimes very serious on the portia tree and whole trees turn black and blighted due to the attacks of colonies of this scale and the consequent black fungus infestation. Badly infested trees should be pruned and given a wash with a contact insecticide.

Palas (*Butea frondosa*).—This small tree, the leaves of which are used in different ways is found subject to some interesting insects. One is a small leaf mining jewel beetle (*Trachys bicolor*, K.) numbers of which often cause mine blisters on the leaves and other a stink bug (*Coptosoma ostensum*,) D. numbers of which sometimes appear in swarms and suck the leaf juice making the foliage dry. A third is a slug caterpillar not very common however. In parts of the Circars, Butea shoots show cospicuous plant galls made by a weevil specific on this plant (*Pachyonyx quadridens*, *Ch.*); the grub is found inside the gall.

Rain tree, Peltophorum, Poinciana, Asoka, etc.—These trees which are nowadays planted as avenue trees along the highway and parks are chiefly subject to the attacks of the bark borer caterpillar (*Indarbela tetraonis*, M., fig. 326) noted already under citrus and other fruit plants. Brownish galleries of this caterpillar made of powdery frass are very commonly seen on the barks of the trees especially near the forks and attachment of the branches. The two mealy bugs *Phenacoccus iceryoides*, G., fig. 327, and *Aspidoproctus xyliae*, G., are also often found covering the tender shoots of rain trees grown along roadsides in Coimbatore.

Teak (*Tectona grandis*).—The two widely distributed and important pests of teak in Southern India are the two leaf caterpillars—the teak defoliator (*Hybloea puera*, C.) and the teak skeletoniser (*Hapalia machoeralis*, W.) found in all teak areas. The former fig. 328 is a fairly stout cylindrical caterpillar brownish green in color with the head end dark ; it pupates in a leaf fold and the moth coming out of it has the upper wings greyish red and the lower wings dark brown with dark orange and red patches. This insect is sometimes found feeding on Bignonia and Millingtonia in gardens, and on teak it is sometimes a serious pest. It is

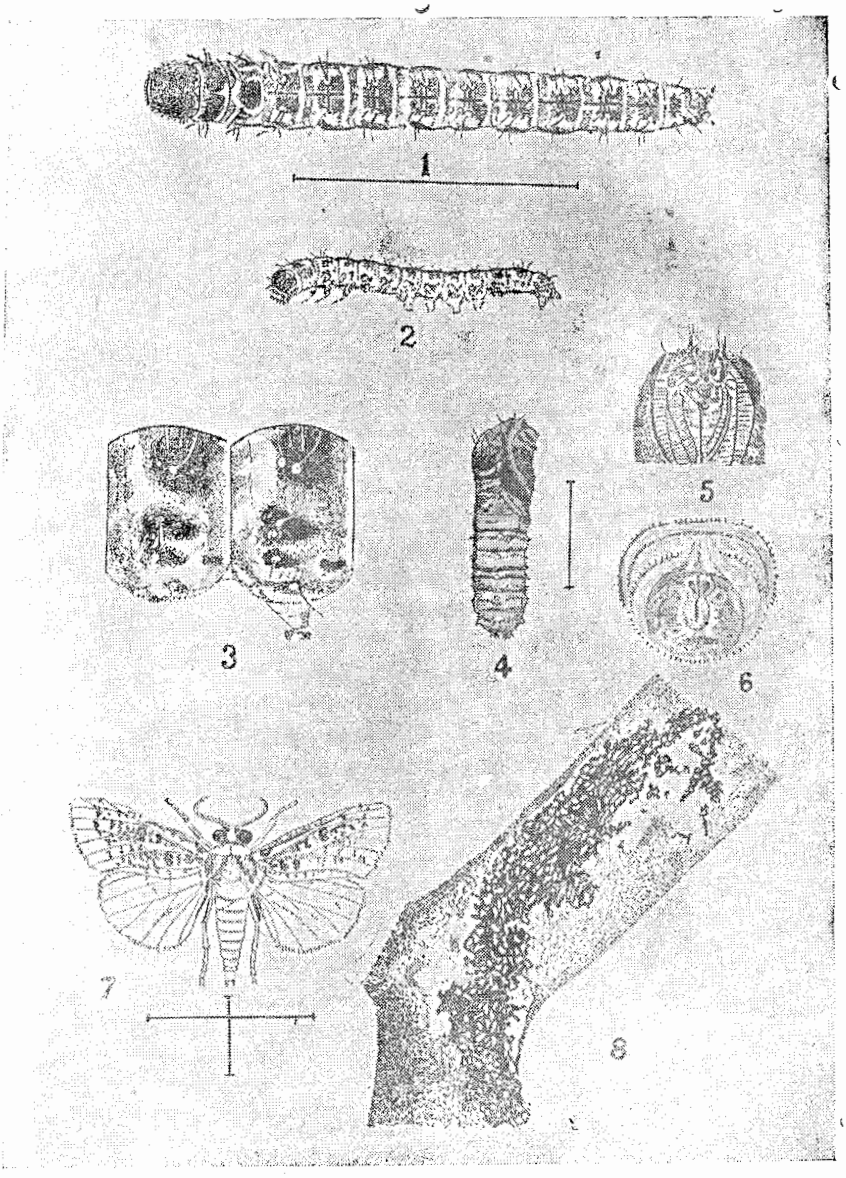


FIG. 326.—THE SHOOT AND BARK BORING ARBELID.
(*Indarbela tetraonis*, M.)

1-3 Caterpillar.
4-6 Pupa
7 Moth.
8 Larval gallery on stem.

[*From Pusa Plate*]

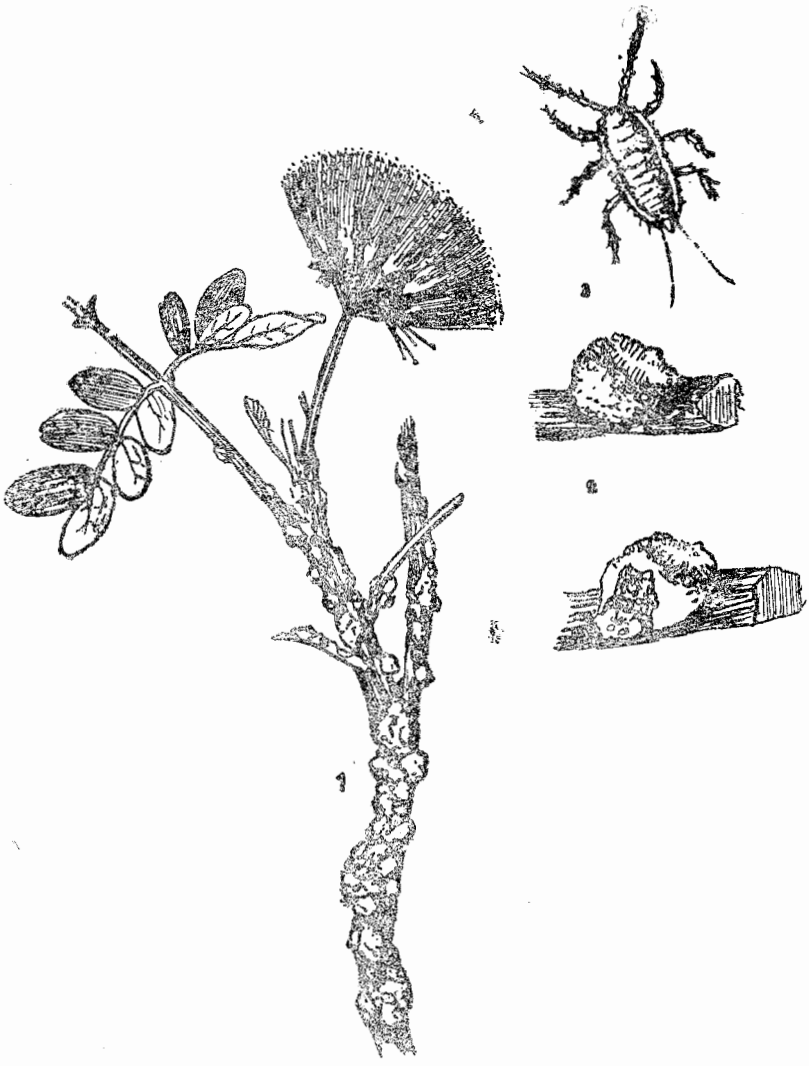


FIG. 327.—MEALY BUG ON RAIN TREE.
(*Phenacoccus iceryoides*, G.)
1. Bugs on tree. 2 Females. 3 Male.

often found in company with its companion noted above—the skeletoniser. This latter caterpillar (*Hapalia*) is slender and elongated and light green in color with a series of purplish spots on either side of a median dorsal yellowish longitudinal streak. The pupa of this creature is also found in a leaf fold. The adult is a small bright yellow moth with some spots and markings and a marginal dark streak on the wings, fig. 329. The caterpillar feeds on the green matter of the leaf leaving only the ribs and thus skeletonises the leaves. These two caterpillars are often very serious in parts of Malabar; though they can be checked on a few isolated trees in compounds and fields, in large teak plantations it becomes a problem of some serious importance in Forest Entomology. The caterpillars of a Cossid moth (*Hypsipila robusta*, M.) is a borer of teak in Travancore. The hairy caterpillar (*Diacrisia obliqua*) and lingicorn beetles (*Coelosterna*, *Dihammus*, etc.) are also noted on teak.

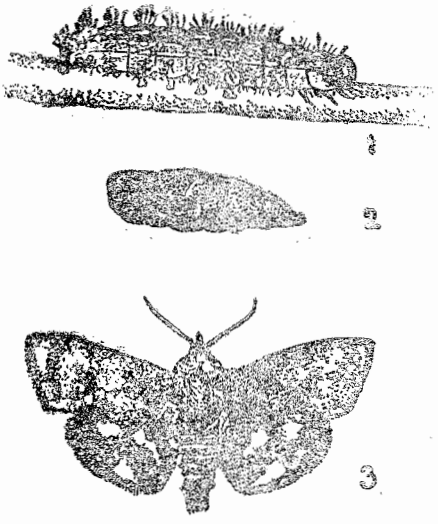


FIG. 328.—TEAK LEAF ROLLER-STAGES.
(*Hybloea puera*, C.)
1—3 Larva, pupa and moth.

[*From S.S.I.*]

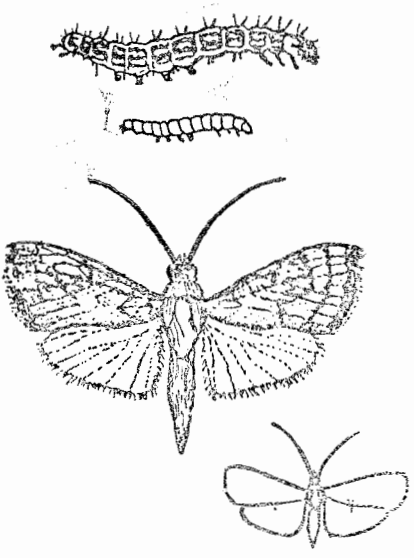


FIG. 329.—TEAK DEFOLIATOR.
LARVA AND MOTH.
(*Hapalia machoeralis*, W.)

[*From I.M. Notes.*

Occasionally, on teak branches, a beautiful shining green jewel beetle (*Psiloptera fastuosa*, F.) is found breeding in parts of the West Coast area (fig. 330). The spotted grasshopper (*Aularches*

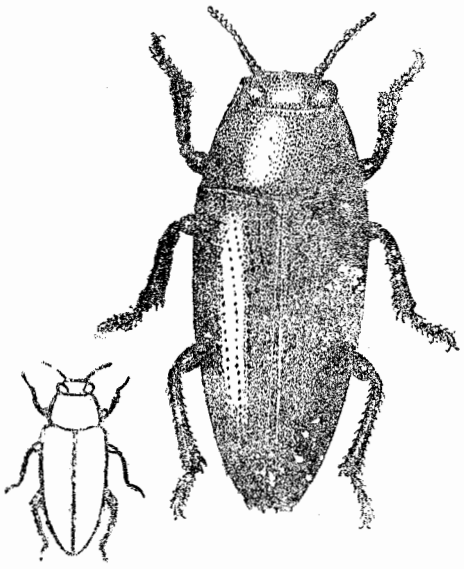


FIG. 330.—JEWEL BEETLE ON TEAK.
(*Psiloptera fastuosa*, F.)

(*From S.S.I.*)

miliaris) of coffee (fig. 292) sometimes attacks young teak seedlings along the West Coast. A mealy bug (*Phenacoccus hirsutus*, G.) has been noted covering the teak shoots in profuse white cottony masses in the Walayar forests of South Malabar. In parts of Tirunelveli, the writer has noted ball-like galls on the branches of teak which are probably caused by (*Cynipid*) gall wasps ; the disease has to be further investigated. Similarly in parts of Malabar, the surface of teak leaves is often found covered with small hairy outgrowths. This is another phenomenon which has to be studied.

Casuarina (*Casuarina equisetifolia*).—The bark caterpillar noted on fruit and avenue trees (*Indarbela tetraonis*, M.) and two or three stem-boring longicorn beetles (*Cœlosterna scabrator*, F., fig. 331, *C. spinator*, F., *Heresium simplex*, G., *Stromatium barbatum*, F., fig. 313, etc.) are the chief pests of this tree. Sometimes termites, bagworms (*Clania* spp.) and mealy bugs (*Icerya* and *Monophlebus* spp.) are also found causing some injury. A root eating greenish caterpillar occasionally attacks the young plants in parts of Thanjavur, along the coastal aria.

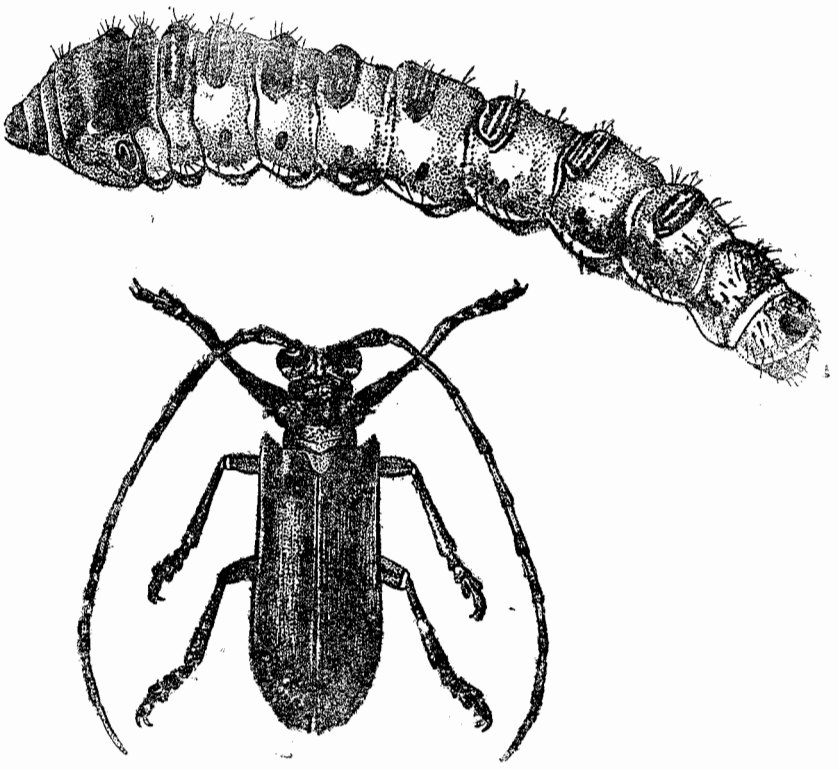


FIG. 331.—CASUARINA BORER BEETLE AND GRUB.
(*Coelosterna scabrator*, F.)

[*From S.S.I.*]

Banyan and Pepul (*Ficus* spp.).—The insects affecting the edible figare found on these also. Sometimes leaf caterpillars (like *Hypsa ficus*, F., figs. 250 and 332) very badly defoliate the leaves; mealy bugs and scales also cover the tender shoots and fruits (see page 301).

Nuna (*Morinda tinctoria*).—This common tree, the bark of which is often used for dyeing purposes, is subject to two or three insects; the commonest of these is the guava mealy scale (*Pulvinaria psidii*, G.) which covers the whole foliage and gives a sickly and blighted appearance to the whole tree. Sometimes the whitish grubs of a very small pale brown beetle (*Hypothenemus plumeriae*, N.) is found boring into the shoots and causing the latter to fade and dry; this damage is often very noticeable. Leaf eating insects on Morinda chiefly include one or two species of green stout hawk moth caterpillars —(chiefly *Macroglossa vialis*, B. and *Rhopalopsyche bifasciata*, B.). The mealy scale and the shoot beetle might occasionally demand some attention.

FIG. 332.—DAMAGE TO FICUS TREE BY HAIRY CATERPILLAR (*Lyppa ficus*, F.) [*From S.S.I.*]

CHAPTER XIX.

Insect pests of Stored Products and Household Insects.

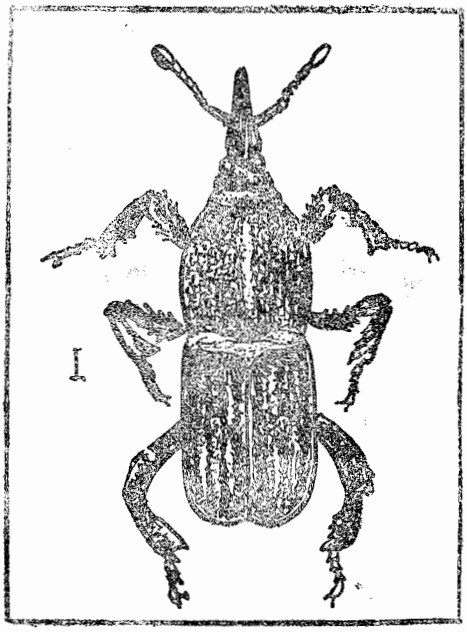
PESTS OF STORED PRODUCTS.

All our farmers are aware of the fact that it is not alone the crop growing in the fields which suffers from insect attacks, but that insects of different kinds also do harm to stored agricultural products. It is well-known that preservation of grains, pulses, etc., for seeds and other purposes is often a serious problem among farmers everywhere. Commodities like grains, pulses, oil-seeds, dry fruits and nuts and various dry vegetable products are the chief materials which suffer from such damage and the injury so caused is often very substantial. Farm granaries, provision and grocery depots, drug stores and flour mills are the chief haunts of these insects. It must, however, be noted that the great majority of them are quite different from those affecting growing crops in their food habits and their activities except in very few cases are almost exclusively confined to stored products. The important products which have to be guarded against such pests are stored grains, pulses, oil-seeds, dry fruits, tobacco, cashewnuts, cardamoms and stored tubers like potatoes, yams, ginger, turmeric, arrowroot, etc. The general life history and habits of most of these insects being similar, the various control measures for all of them are also more or less the same.

The more important of the insects affecting stored products of different kinds are representatives of two insect groups, viz., the *Beetles* and the *Moths*; of these two, beetles are far more represented and of greater importance than the moths. Beetles are also comparatively more destructive because of the fact that both the larva and the adult insect attack the stored material, while among moths it is only the larva or the caterpillar which causes the damage. Though over a dozen different beetles have been noted in association with stored products in different parts of India, the following are the most important and well-known forms among them :—

Beetles.

The rice weevil (*Sitophilus oryzae*, L., fig. 333).—This insect has a world-wide distribution and it is one of those insects with which every farmer, miller or provision dealer is familiar ; it is known



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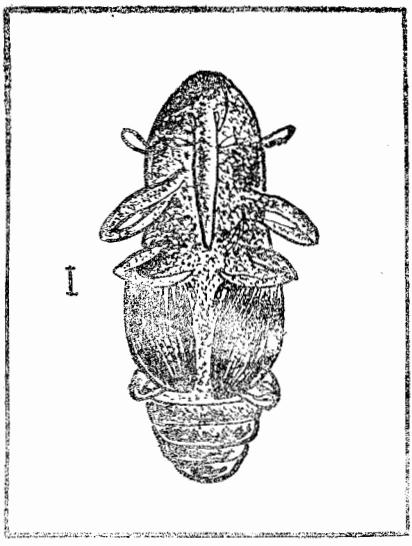

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FIG. 333.—THE RICE WEEVIL—STAGES.
(*Sitophilus oryzae*, L.)

1 Weevil. 2 Grub. 3 Pupa.
[*After Lefroy*]

by several local vernacular names in different places. The insect is a small brownish black weevil about an eighth of an inch long with a cylindrical body and a conspicuous curved beak. Both the adult and the grub not only feed on the stored product but breed and multiply rapidly in the store and at times cause very serious damage. Though it is called rice weevil, the insect is also found infesting other stored grains such as wheat, cholam, maize, etc. Accurate statistics of the damage caused by this important pest are not available but the annual loss to rice dealers in Burma alone is roughly put down to amount to several lakhs of rupees.

Life history and habits.—The female weevil lays several eggs (as many as 50 or 60) and each is laid inside a small groove hollowed out previously by the beetle on the grain surface. The small pale white legless grub hatching out of the egg starts gnawing into the grain and grows inside the same. The full-fed grub pupates inside the grain itself. The larval and pupation periods generally vary according to seasonal changes ; the pupal period varies from 4 or 5 days to 10 or 12 days. Several generations are passed in the year and, in a neglected granary the pest has very favourable facilities to multiply rapidly and cause substantial loss in weight and purity of grain.

The Red grain beetle (*Tribolium castaneum*, H., fig. 334).—This is a small elongate flattish red dermestid beetle about one-sixth of an inch long. It is an extremely common creature and is found to infest almost all stored products like grains, oil-seeds, vegetable powders, oil-cakes, dry fruits, nuts, etc., and it is a special pest of articles like rice, wheat flour, pulses, powders, biscuits, bran, etc.

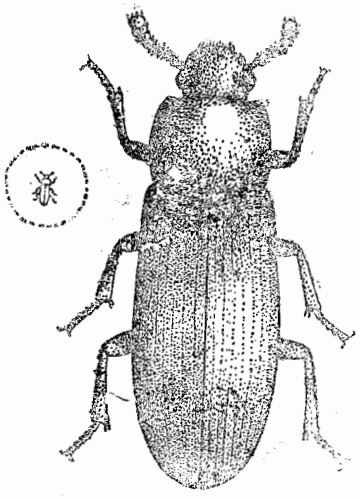


FIG. 334.—THE RED GRAIN BEETLE.
(*Tribolium castaneum*, M.)

[*From S.S.I.*]

The slender elongate white larvæ are also found in infested material. This insect is also fond of museum specimens like dry insects, stuffed trophies, etc., and insect collection boxes not properly disinfected often become subject to its depredations. The small brown saw-toothed beetle (*Oryzæphilus surinamensis*, L., fig. 335)—so-called because of the serrated edges of its thorax, is also occasionally found as a minor pest with the red and other beetles on a variety of stored materials.

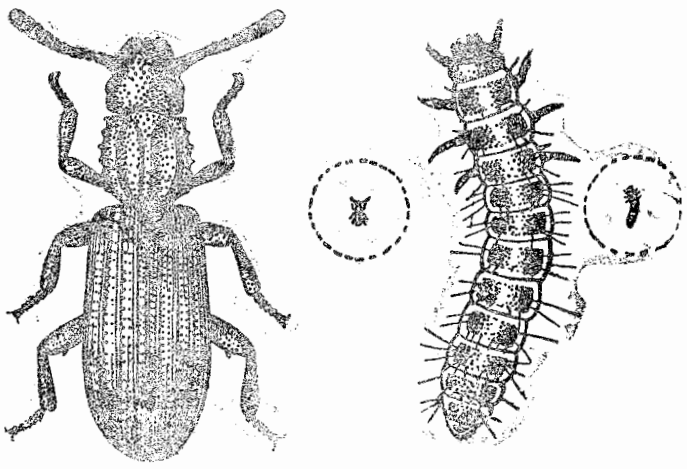


FIG. 335.—THE SAW TOOTHED BEETLE AND LARVA.
(*Oryzæphilus surinamensis*, L.) [*From S.S.I.*]

The Paddy borer beetle (*Rhizopertha dominica*, F., fig. 336).—A dark brown beetle measuring about one-sixth of an inch with a stout globular head. Though not so common as the two insects noted above, it occasionally becomes a serious sporadic

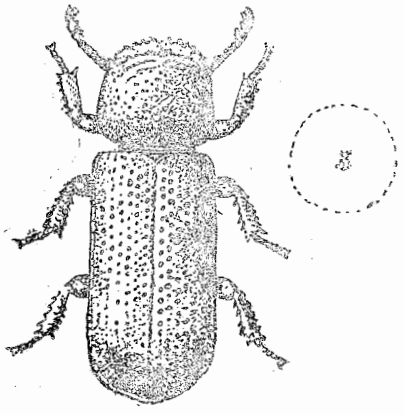


FIG. 336.—THE PADDY BORER BEETLE.
(*Rhizopertha dominica*, F.) [*From S.S.I.*]

local pest of stored paddy (unhusked rice); the adult beetles and their young ones bore through the husk of the grain,

feed on the contents and turn it into chaff. Attacked paddy grains show the round hole made by this pest. It is also sometimes found on other grains in company with other beetles.

The Drug store beetle (*Sitodrepa panicea*, L., fig. 337).—This is a minute brown beetle one-tenth of an inch long with striated upper wings and clubbed antenna. The small whitish grub of the beetle is not hairy. It is found boring into all kinds of dry stores like turmeric, ginger, coriander, etc., vegetable drugs of different kinds and practically all dry vegetable and animal matter like leather stuffs. It also attacks books and records, boring minute round holes in them. This insect is said "to eat anything but cast iron".

The Tobacco borer beetle (*Lasioderma serricorne*, F., fig. 338).—In general form this insect is similar in appearance to the drug store beetle but is smaller in size (one-sixteenth of an inch) without striations on the upper wings and the antenna not swollen at tip; the grubs are very hairy and curved. This is the well known and widely distributed pest of dry tobacco in all forms such as cigarettes, cigars, etc. Both the adult and the grub bore into dry tobacco. It is also known as the 'Cigar borer' beetle. Though it attacks tobacco products chiefly, it has also been found to feed on stored seeds, dry drugs, oil-cakes and roots of ginger, turmeric, etc.

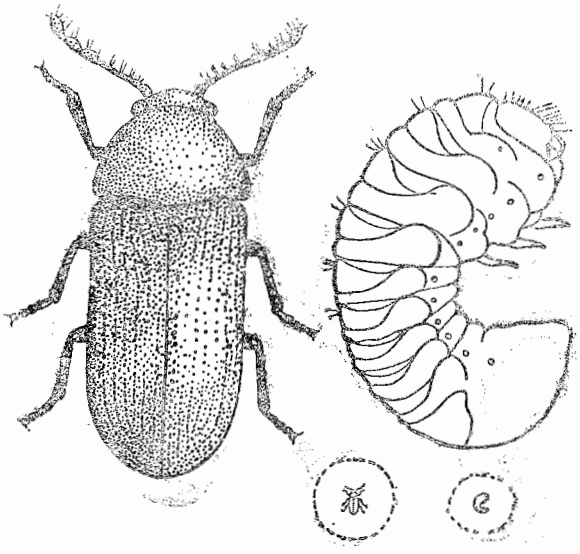


FIG. 337.—DRUG BEETLE AND GRUB.
(*Sitodrepa panicea*, L.) [*From S.S.I*]

Pulse beetles (chiefly *Pachymerus chinensis*, L., fig. 339).—These are small active roundish beetles about one-fourth of an inch long; the body is abruptly rounded behind and the hind legs are stout at the base. These beetles are easily recognized by their dark brown or speckled bodies and are closely associated with

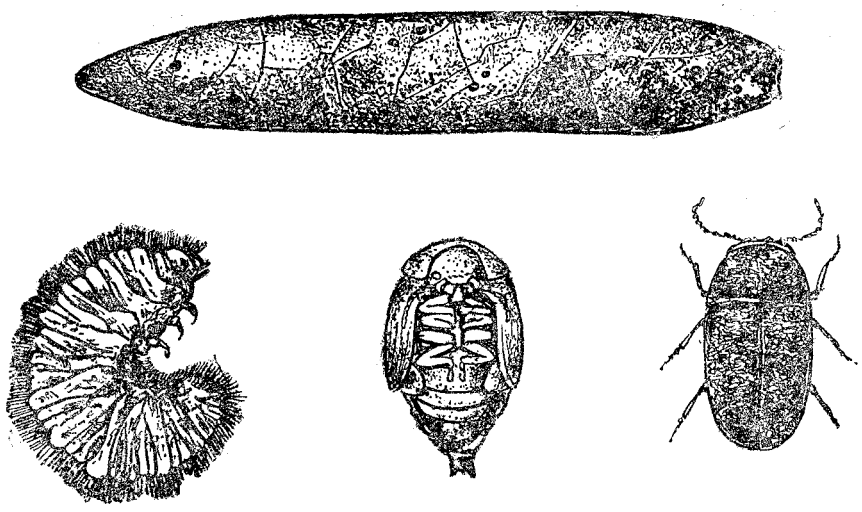


FIG. 338.—THE TOBACCO BORER BEETLE.
(*Lasioderm a serricorne*, F.)
1 Attacked cigar. 2 to 4 Grub, pupa and adult.
[*From S.S.I.*]

pulses of all kinds ; their eggs are laid as minute white scales on infested seeds and the thick-set grubs bore into them by cutting a neat hole. These beetles are often serious and cause appreciable loss to stored pulses like cowpea, grams, lablab, etc., the species noted in some of these cases is found to be *Bruchus phaseoli*, G.

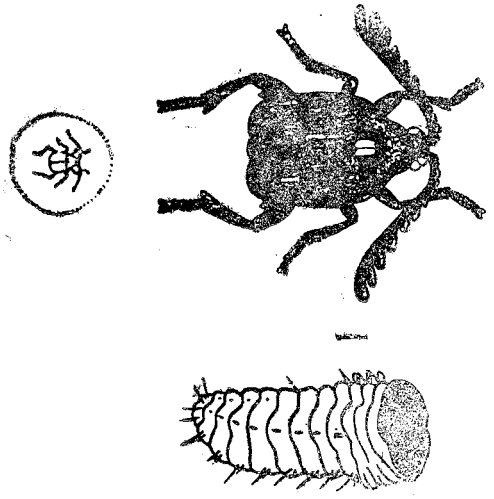


FIG. 339.—PULSE BEETLE AND GRUB.
(*Pachymerus chinensis*, L.)
[*From S.S.I.*]

The Tamarind beetle (*Pachymerus gonagra*, F., fig. 340).—This is a dirty grey beetle belonging to the same group as pulse beetles but bigger than the common species of the group 5–6 mm. long. The grub of this insect burrows into preserved tamarind fruit in provision depots and spoils the same. The full-grown grub constructs a small oval tough silken cocoon for its pupa ; these dirty brown cocoons are commonly found on unseeded tamarind pulp kept in bazaars.

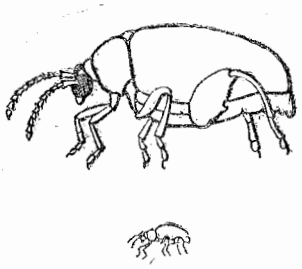


FIG. 340.—THE TAMARIND BRUCHID BEETLE.
(*Pachymerus gonagra*, F.)

[*From S.S.I.*]

A fairly large dark beetle (*Tenebroides mauritanicus*, L., fig. 341) is also found in stored produce ; this is also believed to be partly a pest and partly a predator on other insects.

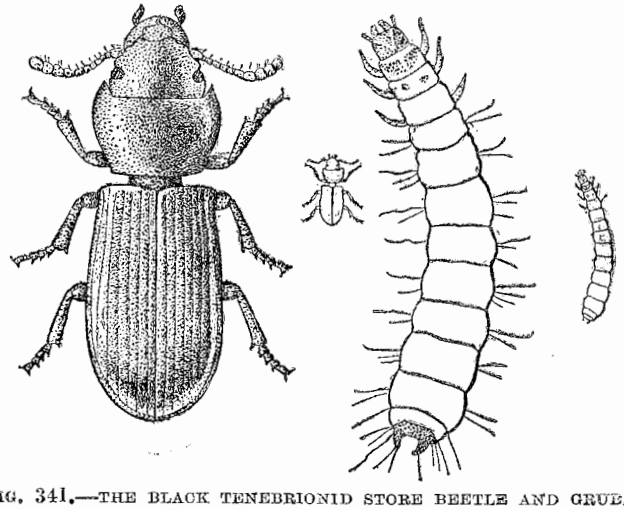


FIG. 341.—THE BLACK TENEBRIONID STORE BEETLE AND GRUB.
(*Tenebroides mauritanicus*, L.)

[*From S.S.I.*]

The dark brown tenebrionid beetle (*Alphitobius laevigatus*, F.) is often found infesting stored groundnuts, millets and fish manure in some places. Another beetle (*Necrobia rufipes*) is also noted on stored groundnuts.

MOTHS.

The important moth pests of stored materials are the Paddy or Angoumois grain moth, a few species of moth caterpillars which are known as meal and flour worms, and the potato tuber moth. Compared to beetles these are fewer in number, though some of them cause very serious damage.

The Paddy or Angoumois grain moth (*Sitotroga cerealella*, O., *fig.* 342) is a very small shining moth found flying in numbers inside infested granaries and causing considerable damage to stored paddy; it is also found in maize and cholam store. As stated above, it is the larva of the moth that bores into the grain and turns it into chaff. It burrows into the unhusked paddy seed and in bad infestations serious loss is caused. The pupa is found in a small cocoon inside the grain.

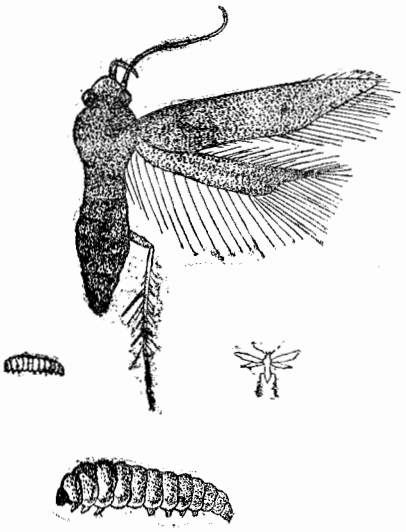


FIG. 342.—THE PADDY STORE MOTH AND LARVA.
(*Sitotroga cerealella*, O.)

[*From S.S.I.*]

The meal worm moths include the rice moth (*Corcyra cephalonica*, H., fig. 343), the Indian meal moth (*Plodia interpunctella*, H.), and the fig moth (*Ephestia cautella*, W.).—One or other of these is commonly found on various stored products such as vegetable powders of different kinds, cholam, maize, rice, grains, seeds of groundnut, cashewnut, etc., often causing appreciable damage. The caterpillars of these are pale reddish brown or whitish worms found remaining inside tubular galleries made up of the powdery matter, the loose grains, etc., all webbed together in a connected mass. The rice moth appears to be one of the commonest of these

meal worms in Southern India and though known as rice moth it infests a variety of other stored products. The fig moth has been noted to infest groundnut seeds and the meal moth (*Plodia interpunctella*, Hb.) often attacks stored cashewnuts with another moth (*Thylacoptila paurosema*, M.) in South Kanara.

The sweet potato weevil, the potato borer moth and the groundnut seed bug noted before may also be brought under the category of stored pests when they attack tubers stored in the godowns. (*See* pages 243 and 247.)

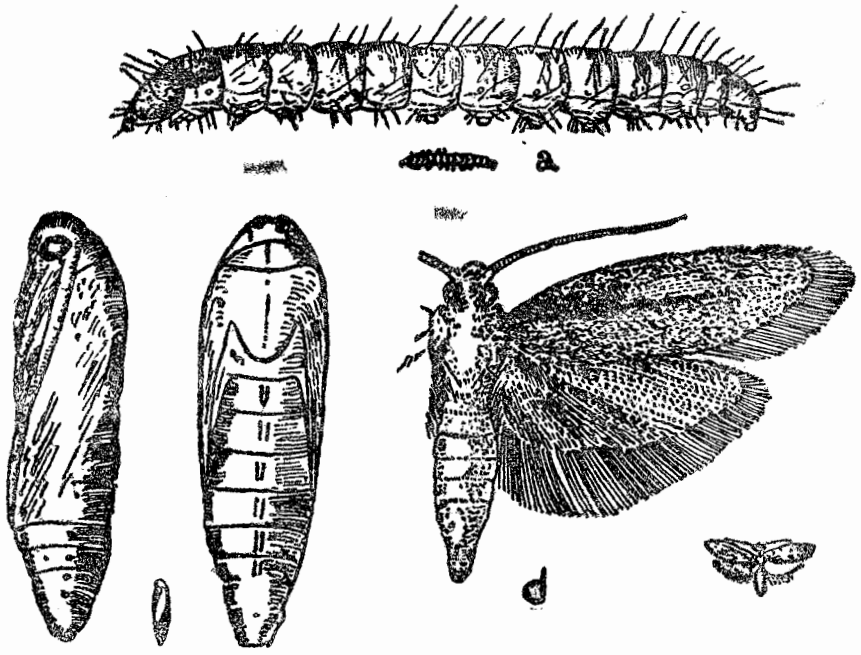


FIG. 343.—RICE MEAL WORM.
(*Corcyra cephalonica*, H.)
(*a*) Larva. (*b*) and (*c*) Pupa. (*d*) Moth.
[*From S.S.I.*]

GENERAL HABITS OF STORE PESTS AND CONTROL MEASURES.

Almost all the insects noted above are more or less similar in their life habits. They breed and multiply so rapidly in the midst of their food that all the different stages are found on the same food material, and once infested, the material is very badly damaged in a very short time. The pests get dispersed also very easily from place to place with consignments of infested material in gunny bags and other containers, and are easily conveyed by road, rail or water way. Except in a few specific cases, the measures to control store pests are similar in the case of all the above insects since their

general habits are more or less alike. The really practical and effective measures for controlling insects affecting stored products and for preventing damage and loss are thorough cleanliness and proper treatment of the material before storage. In the way of preventive measures, it will be helpful to keep in view the following fundamental points in this connection :—

(1) *Proper condition of the cellar, bin or vessel before storage.*—Before a consignment is stored, the store-house or any vessel in which is to be stored should be made thoroughly clean and free from any traces of loose grain, chaff, bran, etc. The corners and floor of the vessels and any cracks in them which often retain bits of matter should be thoroughly cleaned. If this is not done the infection which would linger will spread and in due course spoil the stored material.

(2) *Proper condition of the product to be stored.*—The grain, pulse or other products should be thoroughly dried and made free from husk, chaff or any extraneous matter which would carry the infection into the store-room or vessel. No useful purpose will be served by storing already infested seed in a cellar or bin, however, clean the latter may be.

(3) *Proper condition of the material and the container after storage.*—Once the material has been stored, the granaries, bins or vessels should be completely closed up and remain insect proof; otherwise they are liable to get infested sooner or later. Even the best lot of seeds, kept in very clean vessels, will get infested if kept exposed; baskets, open earthen pots or vessels or loose gunny bags do not keep seeds in good condition. If the above three fundamental conditions are attended to properly, it means that infection is considerably prevented through all the three important channels, viz., the store-room, the stored product and later exposure. In this way, a considerable degree of relief can be experienced from store pests.

Control measures.—It is, however, found that, in some cases, stored products even after bestowing such attention as described above, appear infested with beetles or moths when examined after sometime. This is due to the fact that before storage the products frequently contain the minute eggs or larvæ of some of these insects, which might have escaped our notice and withstood the ordinary mechanical methods of drying, cleaning, etc., and multiplied in storage. To guard against such a contingency, valuable lots of grains, pulses, etc., may be given some special treatment which would destroy all traces of insects lurking in them before storage. One of the best known methods in this direction is what is known as "**Fumigation**" by an insecticide. Fumigation is the process of subjecting insect-infested material to the fumes of a poisonous gas which would destroy all traces of insect in the material to be stored. It has been found that stored products remain perfectly free from insect attacks if they are fumigated and preserved in clean insect-proof containers. It must be remembered, however,

that fumigation does not make stored products immune to further attack if they are not properly preserved after the process. The fumigant commonly used at present for such purposes is a liquid called Carbon-bi-sulphide. The process is as follows : The stored material to be fumigated is put into any vessel or container which can be tightly closed after the operation similar to the one in fig. 68. A measured quantity of the chemical is poured on some cotton wool kept over the grain or other material inside the box and the latter immediately closed. The box is left closed for 24 hours for the insecticide to act and then it is opened and the fumigated stuff freely aired and stored in insect-proof containers. The usual dose is one ounce of the liquid to every fifteen cubic feet of area enclosed and the period is generally 24 hours. During this process, the Carbon-bi-sulphide inside the box evaporates and the heavy gas penetrates the seeds and destroys all insect life. In carrying on fumigation with Carbon-bi-sulphide which is an evil smelling inflammable liquid, some precautions have to be taken and only trained hands should do the work. The chief precautions are : Do not bring any lights near Carbon-bi-sulphide or the fumigation chamber during the process, do not take a bottle of Carbon-bi-sulphide near a fire or naked light nor allow it to get exposed to the sunlight or become heated, and then store the chemical in a properly stoppered bottle and under lock and key. Fumigation with carbon-bi-sulphide should be done in a place where no one can get access during the process. The gas is also poisonous to human beings and as such one should leave the bin or room immediately after pouring the liquid and closing the room. If the dose and the time-limit are properly adhered to, the fumigated material will not suffer in any way-either for seed purposes or for consumption. In farm houses and the seed stores, the provision of a medium sized fumigation box (as in the figure) to treat seeds of different kinds will be very useful and handy. There are also other fumigants now tried in different countries. These include Hydrocyanic acid gas, Calcium Cyanide, Sulphur fumes and Ethylene di-chloride; it is claimed that Ethylene di-chloride has properties which make it not only a very effective fumigant but also a safe substance to deal with. Poisonous substances like Calcium cyanide, Carbon-bi-sulphide, etc., should only be used by men with some experience in that work. Fumigation of large stores of foodgrains with calcium cyanide has been successfully carried out recently by the Madras Government and the problem of preserving large stocks of imported foodgrains has also been solved by this process. Reinfestation of these stocks is prevented by dusting the external surface of the bags with well-known insecticide B.H.C. The use of B.H.C. or D.D.T. smoke canisters also serves the purpose of the dusting but the godowns have to be first rendered airtight. These methods are so perfect that they are now being adopted as a regular routine procedure all over the State. It should also be mentioned here that calcium cyanide is a deadly poisonous chemical

and can, therefore, be handled only under expert technical supervision. The use of the chemicals is recommended only in the case of whole grains like cholam, wheat, maize, etc., and not for rice, various kinds of flour and readymade edible preparations. Later developments in the line consist in the use of fumigants like Chlorosal or Killoptera, Methyl bromide, etc., both of which are highly efficient but absolutely harmless either to the treated material or to human beings.

There are also various other methods in vogue suited to different materials and conditions, such as, physical sterilization with very cold or hot air, or X-rays, storage in underground cellars, etc., to defeat granary pests. ; spraying the seeds and giving a protective film of oil or emulsion to keep away moths and beetles ; use of napthalene in the preservation of seed grains, etc. We also meet with various other local methods of storage and different kinds of vessels, bins, underground granaries, etc., devised and used for the purpose in different tracts ; but very few of them are known to be very effective or reliable in keeping away store pests. For all general needs, however, the instructions given above regarding the preliminary treatment and proper storage of the products will be quite satisfactory. As stated above, a great deal depends upon general cleanliness and the carrying out of the preventive measures suggested above. For further information regarding the insecticides, etc., reference may be made to the numerous papers added on this subject in Appendix E.

Household Insects.

As is well-known, insects of different kinds are often found in our dwellings. Of these, some are, as we have already noted before, creatures feeding on provisions and other dry stores while some show a partiality for articles of clothing, household furniture and fittings, upholstry, books and many such materials.

Among the commonest of household insects in Southern India, we have the cockroaches, the crickets, silver fish, ants, white ants, carpet and powder post beetles and clothes moths. Of these, the important forms which directly affect human beings and domestic animals both as annoyances and disease carrying creatures are flies, mosquitoes, bugs, fleas and lice.

Cockroaches (*Blattidæ*).—These are very familiar creatures found running about in our store-rooms, kitchens, etc., and causing considerable annoyance in various ways. Two or three different kinds are found, but the commonest household form (*Periplaneta americana*, L., fig. 344) is a fairly large creature of a uniform deep brown colour measuring an inch and a half in length : two others sometimes found are the small German roach (*Blatella germanica*, L.) which has two characteristic dark brown streaks on the prothorax and the slightly larger Australian roach (*Periplaneta australasiae*-Fb.) which has a circular yellowish band on the prothorax and

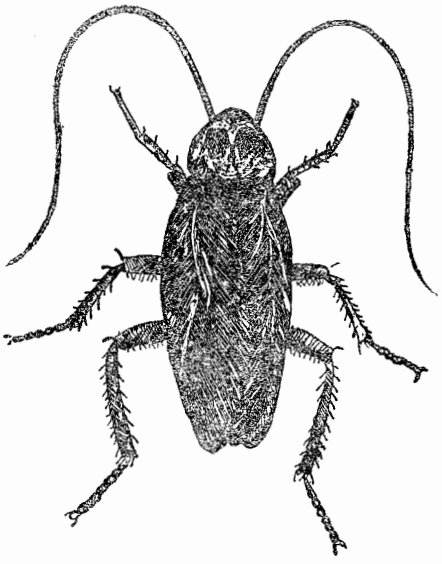


FIG. 344.—THE COMMON COCKROACH.
(*Periplaneta americana*, L.)
[*From S.S.I.*]

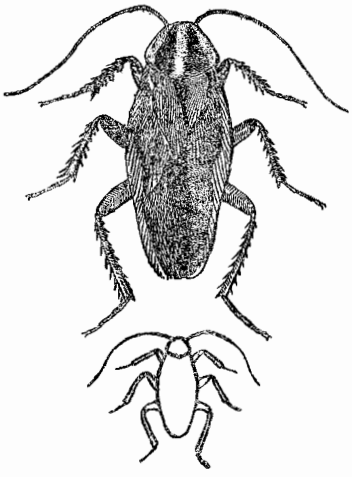


FIG. 345.—THE GERMAN COCKROACH.
(*Blatella germanica*, L.)
[*From S.S.I.*]

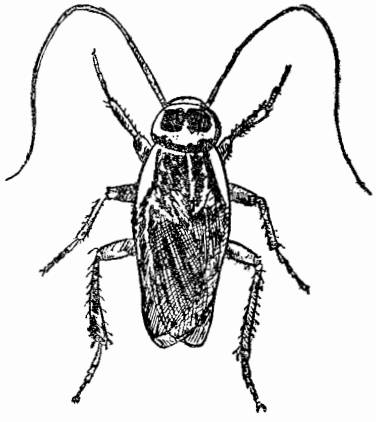


FIG. 346.—AUSTRALIAN COCKROACH.
(*Periplaneta australasiæ*, F.)
[*From S.S.I.*]

a narrow yellowish patch on each forewing, figs. 345 and 346. Cock roaches lay eggs in characteristic seed like cases (*ootheca*) each case containing a number of eggs; these egg capsules are often found sticking out of the abdomen of the female cockroach as it moves

about. The young ones take about three months to attain maturity and pass through six moults during that period. Their habits in houses are well known ; they are nocturnal and fond of warm and moist places, they touch, taste and pollute everything they meet with and leave a nasty unpleasant odor in their haunts. The best method of control against these creatures is the use of poison traps—the best poison bait being *Sodium fluoride*—a white powder. It can be sprinkled in the haunts of cockroaches either alone or mixed with equal parts of flour. The stuff is poisonous and has therefore to be handled and used carefully. Borax is also sometimes used, but it is not so effective as Sodium flouride.

Crickets (*Gryllidæ*, *fig.* 14).—Crickets have almost the same habits as cockroaches but are not so ubiquitous and audaceous as the latter. The common house crickets (*Gryllus sp.*) are grey brown in color with the characteristic tail processes. The mole cricket (*Gryllotalpa africana*, *L.*, fig. 85) is often found in damp corners in houses. Crickets are also nocturnal and make a shrill disturbing noise from inside cracks in walls and door-frames and leap long distances. These are sometimes difficult to control but can be checked to some extent by trapping them in basins of water kept in their haunts or with poison baits.

Silver fish (*Lepisma* sp. fig. 347).—This is an active glistening greyish insect which is commonly found behind pictures on walls, books, shelves and washed clothings which have not been disturbed for some time. This creature which belongs to the group Aptera is wingless, has a soft scaly body and the three characteristic

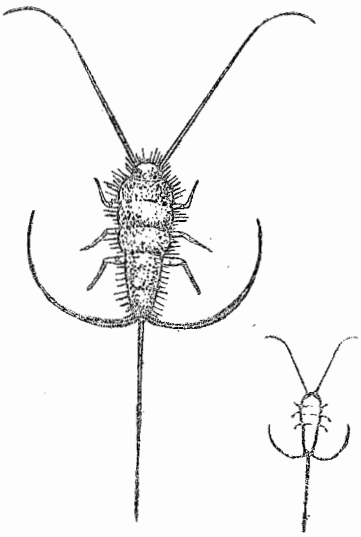


FIG. 347.—THE SILVER FISH.
(*Lepisma sacharina.*)

[*From S.S.I.*]

anal processes. Different species of this common insect are also found inside granaries and store houses where at times they multiply remarkably and assume serious proportions. Thorough cleaning of the haunts and sprinkling of phenyl water will control these creatures. In the case of books and pictures (*see* fig. 348), book solution may be used. Naphthalene or camphor may also be used for clothings, etc. Sodium fluoride paste can also be used as a bait, but should be carefully handled since it is poisonous.

Carpet beetles (*Dermestidae*).—These are small beetles which are often destructive to carpets, upholstry, brushes, silk and woollen goods and even museum specimens of insects, etc. The larvæ are dark brown or black and wooly (hence known as wooly bears). The common household ones found in Southern India are two small spotted forms (*Anthrenus vorax*, *W.*, and *A. pimpinellæ*, F.

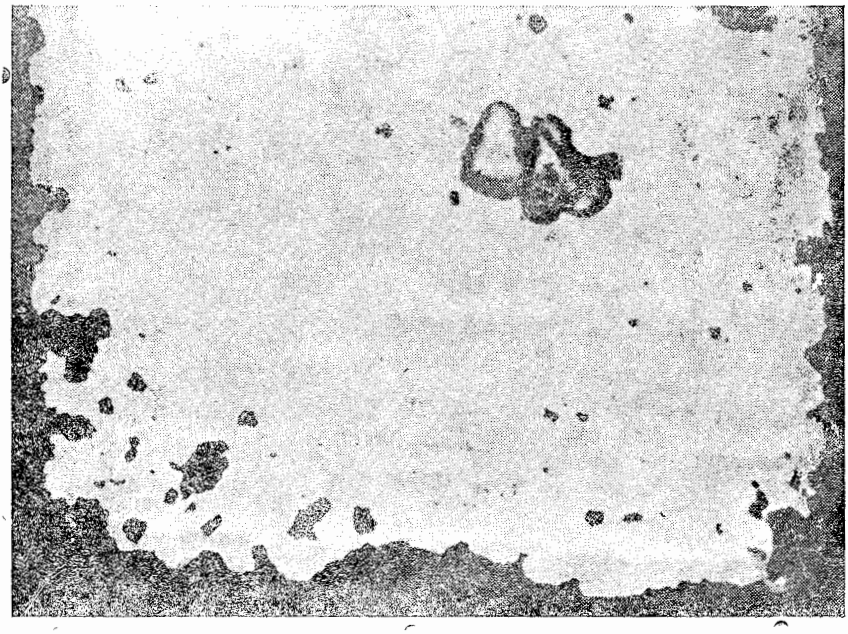


FIG. 348.—DAMAGE BY SILVER FISH.

[*From S.S.I.*]

(*see* fig. 349); *A. fasciatus* has been reported from army clothing depots and a larger and darker species *Dermestes vulpinus*, F. is often found attacking fish guano, silk cocoons, etc. The same control measures adopted for the fish insect can be employed against these beetles also. In some of the hill plantations in Southern India and in places along the foot hills of the Western Ghats a dark brown, tenebrionid beetle (*Lyprops curticollis*, F.) is, during certain seasons found in swarms attached to the wood-work in buildings, rest-houses etc., it has not however been noted to cause any harm so far.

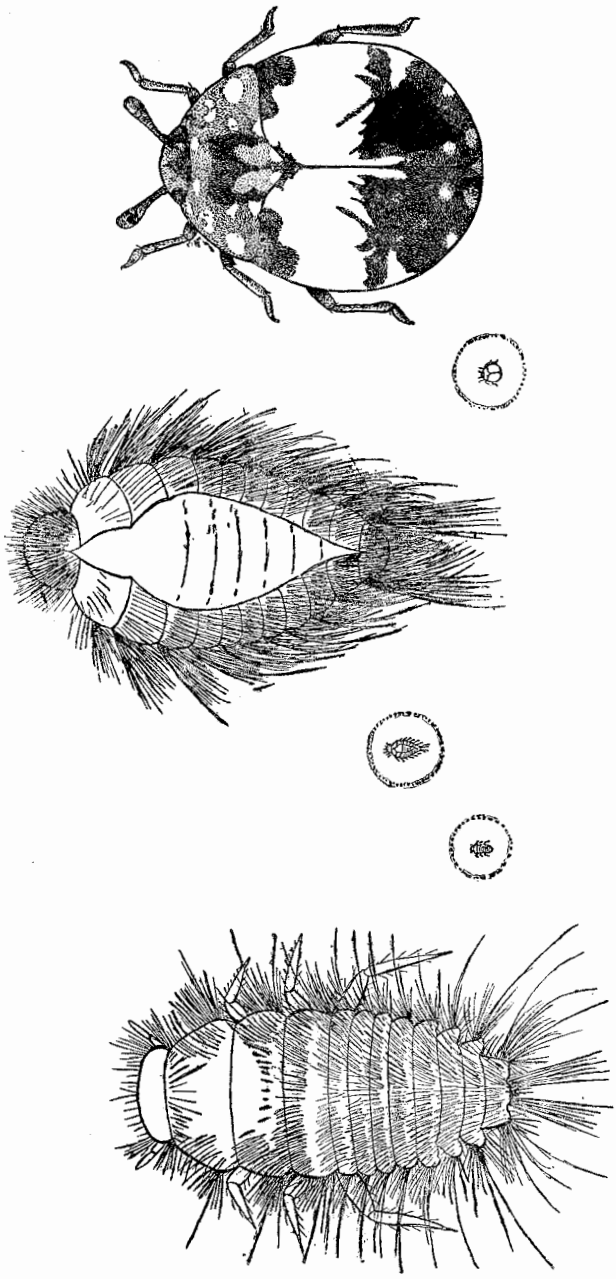


FIG. 349.—CARPET BEETLE (GRUB, PUPA AND ADULT).
(*Anthrenus pimpinella*, F.) [*From S.S.I.*]

Ants (*Formicidae*, *figs.* 350 *and* 351.)—Ants of different kinds are now and then found as annoyances in households ; they attack all kinds of foods and provisions, especially sweets, dairy products, etc. The common household ants in Southern India include the species of small red ant Monomorium (*M. gracillimum*, S.) a reddish brown odoriferous ant (*Myrmicaria brunnea*) another species (*Solenopsis geminata*, F. fig. 350) and a few very minute dark forms. The

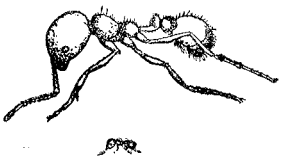


FIG. 350.—THE HOUSEHOLD RED ANT. (*Solenopsis geminata*, F.) [*From S.S.I.*]

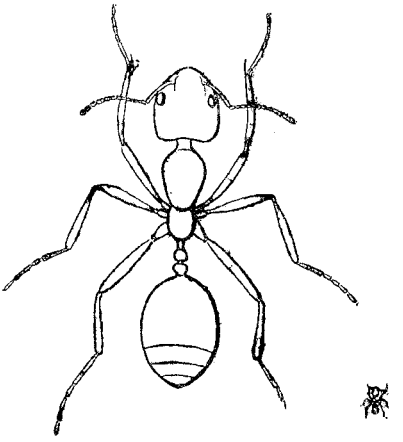


FIG. 351.—THE SMALL HOUSE ANT. (*Monomorium gracillimum*, S.) [*From S.S.I.*]

black ant (*Camponotus compressus*, F.) also haunts houses. Ants and termites being social insects the radical remedy against them is to destroy their nests containing the queen ant and all the other inmates. If the nests are located they can be fumigated with Carbon bi-sulphide or Sulphur fumes with some apparatus like the White ant exterminator (fig. 352) or merely by pouring the Carbon bi-sulphide and closing the hole with wet clay. Temporary relief can be obtained in households by baits and traps of different kinds such as those made of Tartar emetic, soda, arsenate etc., etc., (*see* Appendix). DDT dust or DDT in kerosene has a remarkable effect against most of these household pests.

Household hairy caterpillar.—In the sub-montane districts, especially along the West Coast during the period July to November a small black hairy caterpillar, which feeds on mosses and lichen is often found as a domestic pest causing considerable annoyance to the inmates of houses. The adult insect is a pretty small moth (*Asura conferta*, W.) with orange colored wings which comes to lights in numbers, fig. 353.

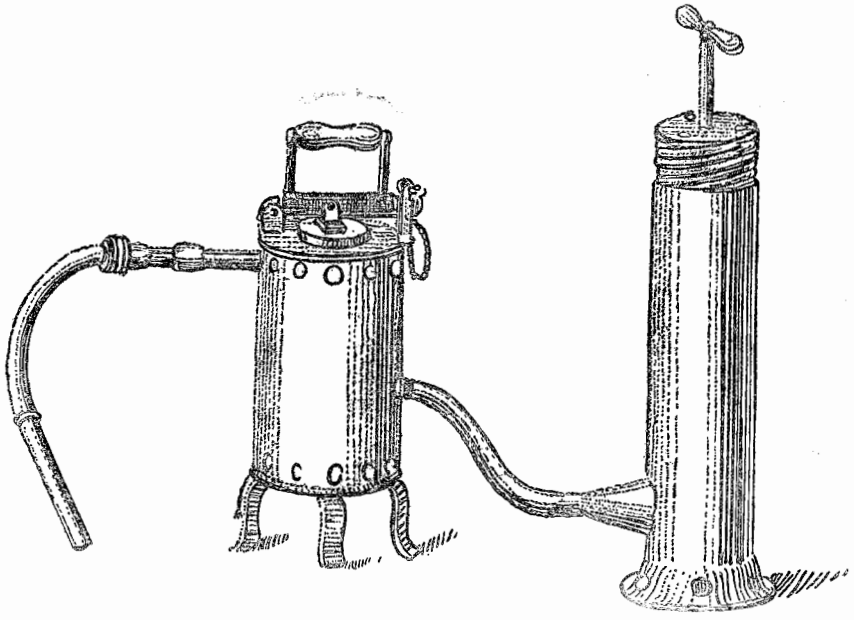


FIG. 352.—ANT EXTERMINATOR.

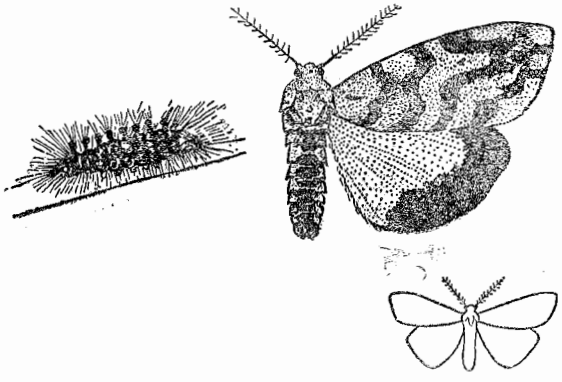


FIG. 353.—THE HOUSEHOLD CATERPILLAR AND MOTH.
(*Asura conferta*, W.)

[*From S.S.I.*]

Wasps and Bees.—Hornets and bees which occasionally build their hives near and inside human dwellings often become a nuisance to men. The rock bee (*Apis dorsata*) and the yellow banded wasp (*Vespa cincta*) are the commonest of these in South India ; often the carpenter bees (*Xylocopa spp.*) also become serious in the wood-work of houses. The only practical and easy remedy against them is to burn the nests with a torch during night time when the colony is inactive.

White ants (*Termitidae*) *and furniture beetles* (*Bostrychidae*).—Though belonging to a different group (*Isoptera*) and structurally quite different, white ants are social forms like ants and have practically the same habits. In South India, we have, in addition to species which attack growing plants (fig. 354), forms which are household pests affecting wood-work of all kinds, furniture, picture

FIG. 354.—TERMITES ON TREE STEM.

[*From S.S.I.*]

frames, etc., and even books, pictures, clothings, etc. To prevent termite attack we have to attend to at least one of these principles, viz., make the structure or material to be protected inaccessible to termites, use wood which resists their attack or not allow termite breeding in the vicinity.

Similar to white ants small reddish and dark brown beetles (*Bostrychidæ*) are often found attacking cane, bamboo and other

wooden materials of the household; in bad cases the material is reduced to powder by these beetles and their grubs. They are known as powder post beetles. The common species known belong to the genera *Sinoxylon* and *Dinoderus* (fig. 355). The control against these insects is more or less similar to that against termites. As preventives, wood-work used in buildings, furniture, etc., should be well seasoned or naturally resistant and those which have to be in direct contact with the ground may be soaked in some preventive solutions of creosote or other materials which will deter these creatures from attacking wood.

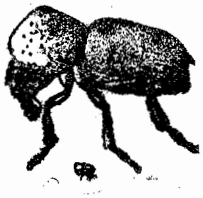


FIG. 355.—FURNITURE BEETLE.
(*Sinoxylon sudanicum*. L.)
[*From S.S.I.*]

Clothes moths (*Tineidæ*).—Furs, woollens, trophies, etc., and sometimes linen, when not attended to for a long time are found to be attacked by slender caterpillars of these small moths; the caterpillars generally move about enclosed in small cases of cotton, wool or silk and feed on the fabrics. The common ones in South India are a light greyish brown moth (*Tinea pachyspila*, M., fig. 356) and

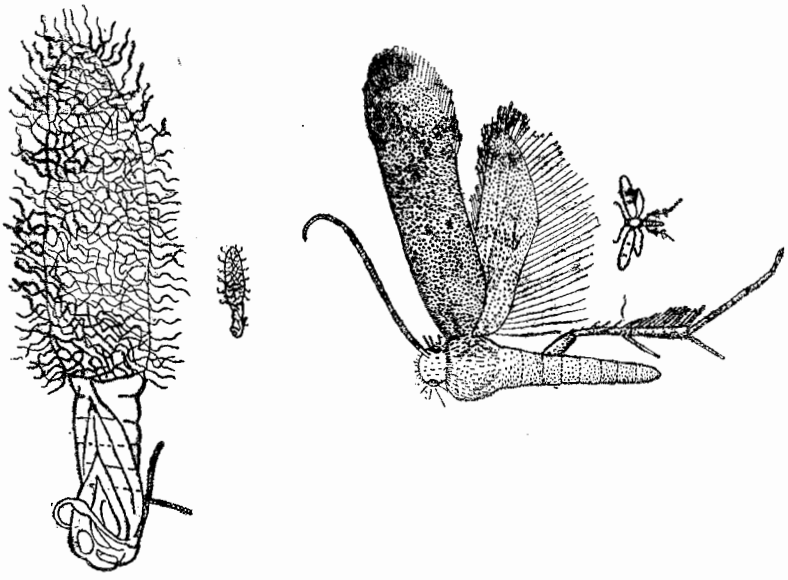


FIG. 356.—THE CLOTHES MOTH AND PUPA.
(*Tinea pachyspila*, M.)
[*From S.S.I.*]

the widely distributed black and white winged clothes moth (*Trichophaga abruptella*, L., fig. 357). Constant handling and the use of naphthalene, camphor, etc., will control these insects. Fumigation of the infested material or room is also an excellent measure.

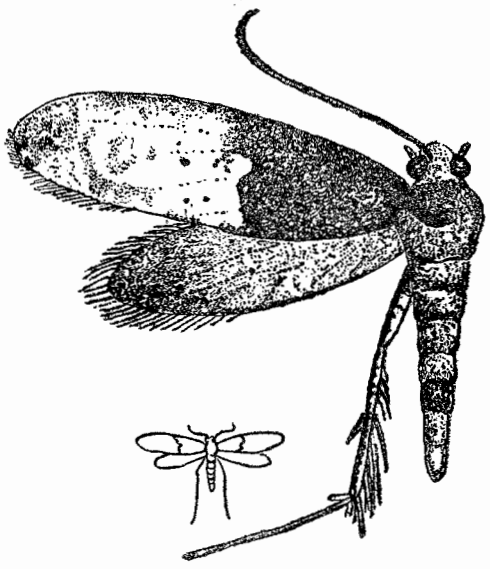


FIG. 357.—THE BLACK AND WHITE CLOTHES MOTH.
(*Trichophaga abruptella*, W.)
[*From S.S.I.*]

CHAPTER XX.

Pests of cattle and other Domestic Animals.

In addition to the insects causing damage to his growing crops and stored provisions the farmer has to contend against insects of different kinds attacking his cattle and other domestic animals like sheep, horses, poultry, etc. These insect pests not only cause direct injury and annoyance to the animal hosts they attack, but in many cases they also cause diseases and functional troubles in them. The more important of these pests are representatives of certain groups of insects specially adapted for life as parasites on warm blooded animals, and include creatures popularly known as horse flies, bot flies, biting flies, gnats, flesh maggots, fleas, lice, bird lice, ticks, etc. The insect order including the most important of these is the *Diptera* ; others include the biting bird lice (*Mallophaga*) allied to the *Neuroptera*, the fleas (*Siphonaptera*) near the Diptera and the blood-sucking lice (*Anoplura*) allied to the bugs (*Rhynchota*). In addition to these we often come across some important non-insect pests of cattle, viz., ticks and mites. Occasionally cattle grazing in forest areas often become subject to the attacks of bees, wasps, blister beetles and spiny and hairy caterpillars also.

The trouble and annoyance caused to milch and work cattle by such pests and the loss of condition in such animals are very serious in many places, and the annual loss sustained in India on this account is estimated at many lakhs of rupees ; especially in forest areas cattle suffer very seriously and lose condition very appreciably. Dogs infested with ticks and poultry suffering from lice very soon lose their health and even become prey to some infectious diseases.

Among fly pests of cattle, there are different categories met with; the more important of these are the Gad flies (Tabanidæ), Horse flies (Hippoboscidæ), Bot flies (Oestridæ), the Flesh maggots and the Biting flies (included under Muscidæ) and the Mosquitoes (Culicidæ). It may also be added that, of these different kinds, some of the groups include insects which are pests only in the adult condition while among others it is only the larval stage or the maggot which causes real injury to its animal host.

The Gad flies (*Tabanidae*).—These are stout built active flies. The males have large eyes meeting at the median line. Among these flies the males generally feed on the nectar of flowers and it is only the female which is blood thirsty and attacks cattle and sometimes even men. The early stages of these insects are generally

spent in places where there is some water. The eggs are usually attached in masses of hundred or more to aquatic plants (fig. 20) and the larvæ are generally found wriggling in moist soil. These larvæ are cylindrical and elongated like worms with the body having transverse ridges and pointed at both ends. They feed on the small organisms found in the moist soil and continue in that manner for over a month or two and then pupate near about their larval haunts. The commonest forms found in South India are species of Tabanus (*Tabanus striatus*, F., fig. 358 a well-built grey fly with three rows of whitish marks on the abdomen) including the common ones found in the plains and the banded winged species of *Chrysops* (*Chrysops dispar*, F.). These are generally found hovering about cattle-yards, stables and grazing grounds ; the flies frequently visit the hosts and suck blood. In the forests and hills, forms like *Haematopota* and *Corizoneura* (*Pangonia*) are noted ; the latter include hairy forms with remarkably long and pointed proboscis which, in some cases (as in *Corizoneura taprobane W.*, fig. 359) is as long or longer than the whole body and is said to pierce the skin of wild animals like elephants, bison, etc. On the Bababuddin hills, the writer has found species of *Haematopota* (*H. montana*, R.) viciously attacking even men.

Horse flies (*Hippoboscidae*).—These are leathery flattened flies with wings and having the legs well supplied with strong claws which help them to attach themselves to their host (fig. 360). Though provided with wings and able to fly, these creatures generally remain clinging on to the skin of their host ; when disturbed they fly out for a second and again settle on some other part of the host's body. Sometimes numbers of them are found attached to the sides of the neck in cattle. Here again it is the adult fly which is the pest—sucking blood from its host. The life history of these creatures is peculiar. Instead of laying an egg like many other flies, the female insect deposits a fairly mature larva which changes very soon into a short roundish puparium from which the fly emerges. Such flies which exhibit this peculiar features in their life history are known as *Pupipara* and come under the family *Hippoboscidæ*. The common forms include species with a yellowish or reddish brown body often marked with spots and bands—Hippobosca ; (commonest species *H. maculata*, L. and *H. capensis*, O.) ; these attack cattle, horses, dogs, etc. A degenerate apterous form (*Melophagus ovonus*) is known to attack sheep in different parts of India.

Bot flies (*Oestridae*).—Unlike the flies noted above, these are insects where the larva is the real pest, living often as an internal or subcutaneous parasite of the host. The flies are sombre coloured forms with heavy bodies, rudimentary mouth parts and large heads and they are rarely seen. The life histories of these flies are

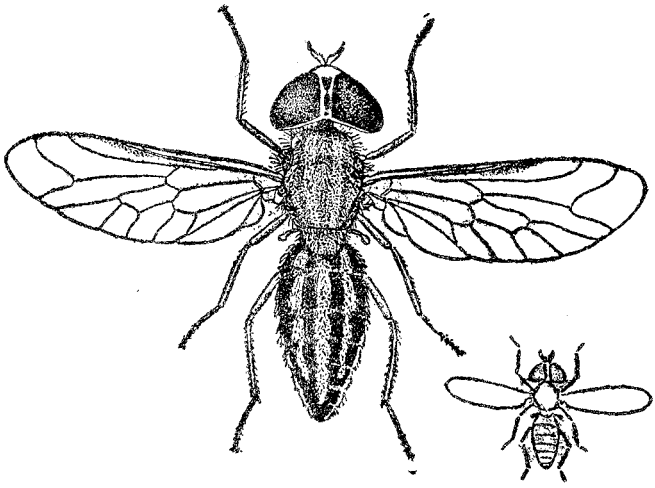


FIG. 358.—A COMMON GAD FLY.
(*Tabanus striatus*, F.)

[*From S.S.I.*]

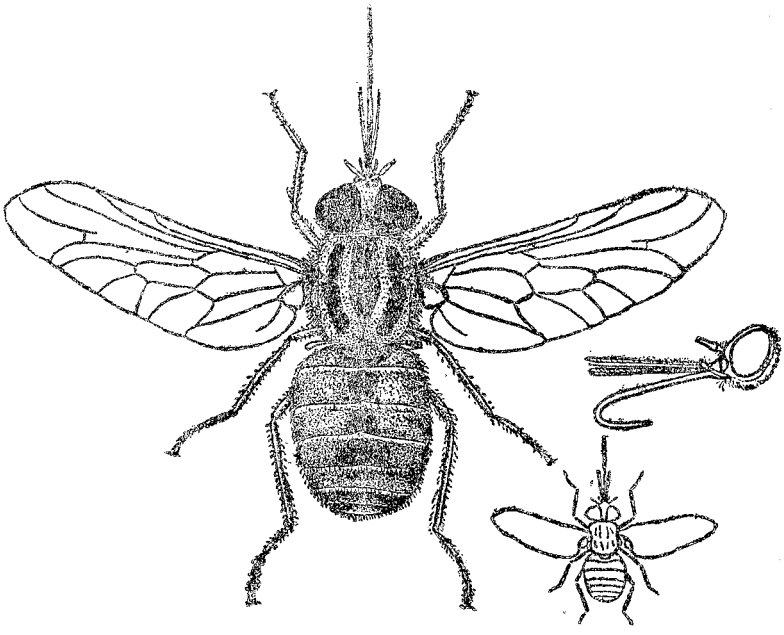
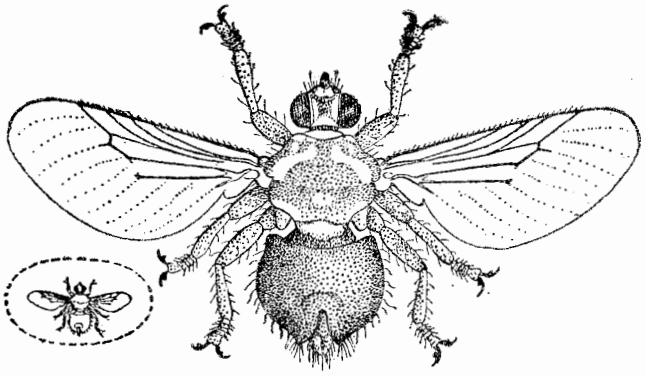


FIG. 359.—THE HILL GAD FLY.
Pangonia (*Corizoneura*) *taprobane* W.

[*From S.S.I.*]



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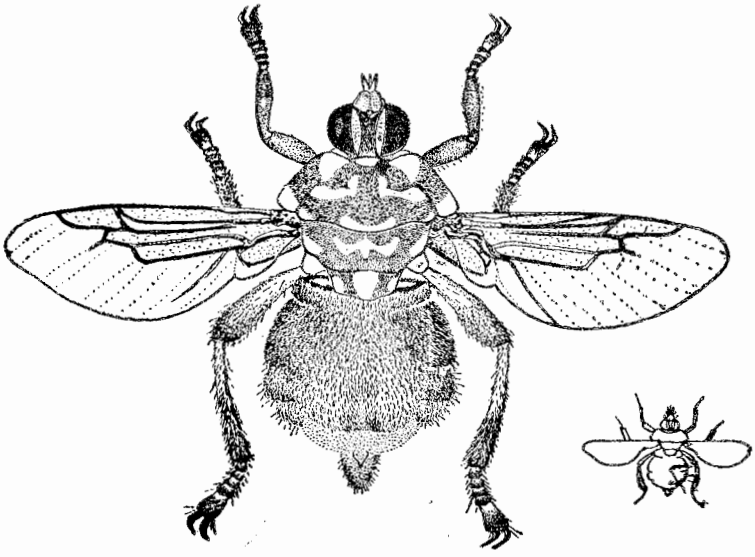

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FIG. 360.—HORSE FLIES.

1 *Hippobosca capensis*, B. 2 *Hippobosca maculata*, 1.

[From *S.S.I.*]

extremely interesting and wonderfully adapted to their peculiar parasitic habits. Three important types are well-known:—(*a*) the Horse bot fly (*Gastrophilus equii*, F.) ; the female fly attaches its eggs singly on to the hairs of the horse ; the just hatching embryo causes some slight irritation and the horse licks the spot with the result that the young larva is transferred unconsciously to its alimentary tract. In this manner, numerous larvæ find their way into the stomach of the horse where they grow feeding on the mucous secretions and causing trouble to the host. When about to pupate, the full-fed maggot escapes to the soil with the horse dung and pupates underground. The horse bot is not a very common insect in South India though in North India the species *Gastrophilus intestinalis*, deG. is said to be common. (*b*) *The sheep bot* (*Oestrus ovis*, L., fig. 361), this fly lays its eggs or even maggots as in the case of horse flies into the nasal chambers of the sheep ; the larvæ often find their way into the other chambers of the head and when many such maggots get in, great annoyance and trouble are caused and the sheep suffers. The full-fed-maggots either crawl out or are expelled as a result of the sneezing by the sheep and pupate under the soil. This insect is fairly common in South India. (*c*) Ox bot or warble (chief Indian form *Hypoderma lineatum*, deG) ; this fly generally attacks cattle and the larvæ are known as warbles. Though widely distributed in Northern India warble flies are not very common in Southern India. The eggs are attached to hairs of the body of the host and the young larvæ hatching out grow into fleshy maggots which cause the typical swellings with inflammation on the skin of the host. The maggot remains in this pouch for some time and when about to pupate, pierces the skin of the host, and through this hole it drops to the ground where it changes into the pupal stage. These warbles on the body make the ox, goat or cow lose condition and become unhealthy ; especially this is the case in milch cattle where milk production is considerably reduced. Even after death, the hides of these animals show the warbled spots and are known as warbled hides which do not command good prices. Similar bot larvæ have occasionally been noted in India on other animals like camel, buffalo, deer, rhinoceros and even the elephant. In Southern India, the occurrence of the Elephant bot (*Cobboldia elephantis*, C.) has been recorded from the Anamalai hills. There are also stray records of Oestrid larvæ found under the skin of human beings.

Blue bottles, flesh and biting flies.—Blue bottles are common flies having blue and green colours ; the larvæ are generally found on exposed flesh or in wounds and sores on cattle ; in bad infestations of these maggots cutaneous diseases are caused. These flies are sometimes found attacking exposed and neglected wounds in man also. *Lucilia serinissima*, F. is a common Southern Indian form. The common blue bottle fly with red cheeks (*Pycnosoma flaviceps*, M., fig. 362), commonly found on night soil and near slaughter houses is closely allied to *Lucilia*. The flesh flies (*Sarcophagidæ*) are also found with blue bottles, and chiefly include the species.

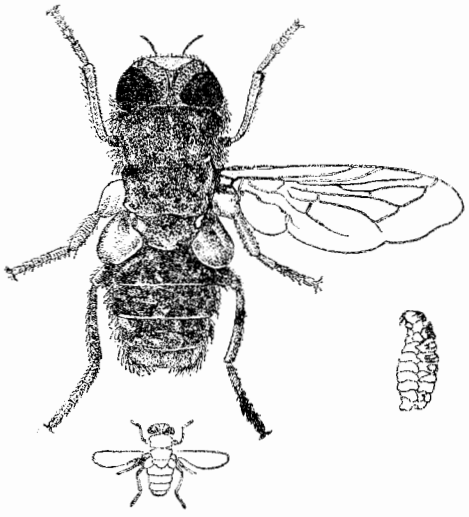

FIG. 361.—THE SHEEP BOT FLY AND MAGGOT.
(*Oestrus ovis*, L.)

[*From S.S.I.*

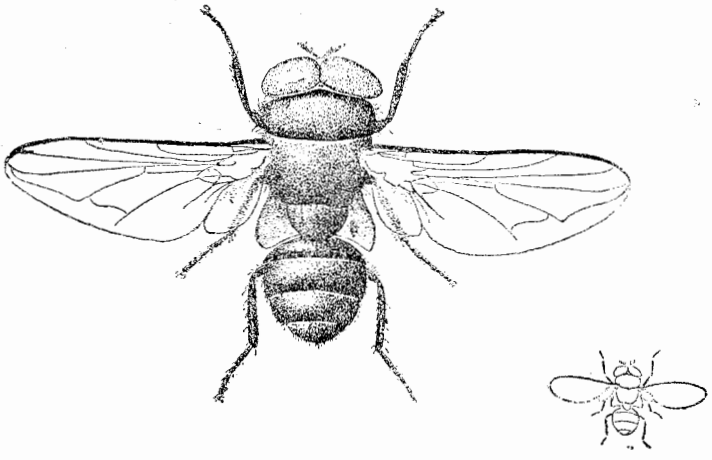

FIG. 362.—THE BLUE BOTTLE FLY
(*Pycnosoma flaviceps*, M.)

[*From S.S.I.*]

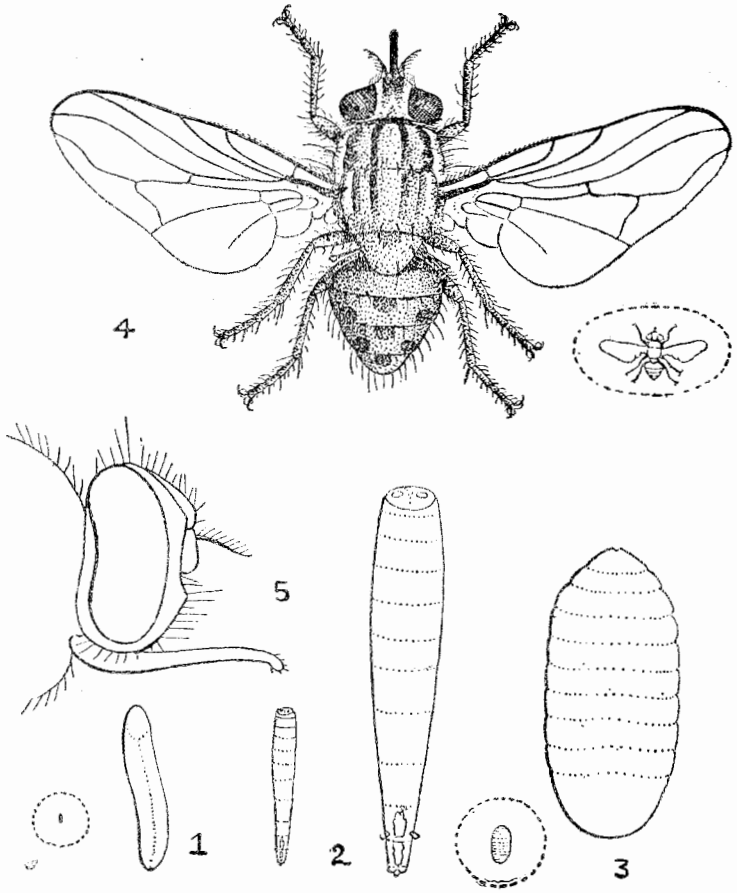

FIG.363—THE STABLE FLY.
(*Stomoxys calcitrans. L*)

1 Eggs
2 Maggots.
3 Pupa.
4 Fly.
5 Head of fly.

[*From S.S.I.*]

Sarcophaga lineaticollis in South India. The biting flies are insects which are closely allied to the housefly in general features, size., etc. but they differ from the housefly in having mouth parts adapted to pierce the skin and suck blood, a character absent in the former. These include the stable fly (*Stomoxys calcitrans*, L., fig. 363), a light grey fly looking very similar to the housefly but with a distinctly pointed piercing proboscis. It is a well-known insect all over the world and is very common all over Southern India, frequenting cow-sheds and stables. The life history is exactly similar to that of the housefly. The younger stages are found in horse and cattle manure and often in other moist situations. This is one of the important biting flies of cattle in Southern India ; two others Lyperosia (*L. exigua*, M.) and Phylæmatomyia (*P. insignis*, *A**) are also found in company with the stable fly. In some tracts mosquitoes of different kinds also annoy cattle considerably.

Bird lice (*Mallophaga*).—These are insects the activities of which are almost entirely confined to poultry and they are quite different in habits and life history from flies or typical lice. They are not creatures which suck blood ; their mouth parts are mandibulate and as such they cut, bite and scratch the skin, feathers, body, scales, etc., of their host. They have hard and horny bodies which are somewhat flattened and they are all wingless forms. Some of them run about the body of their hosts while some remain attached to hairs of feathers of the host. Though the majority are pests on birds, a few others have been noted to attack also mammals like sheep, dogs, horse, etc. The life history is usually spent on the host animals themselves. Different species of these insects are found on various birds. The annoyance caused to fowls and chicken by these parasites is often very serious ; badly infested birds can be commonly found rubbing their bodies in ash-pits, etc., to get relief from the irritation caused by these lice (fig. 364). The common fowl louse (*Menopon pallidum*, N.) distributed all over the world is a typical example of this group.

Blood-sucking lice and fleas.—Different kinds of these insects very closely allied to the forms affecting man are also found infesting cattle and other mammals like dog, hog, squirrels, etc. The common species of lice attacking cattle, etc., is the buffalo louse (*Hæmatopinus tuberculatus*, N. and G., fig. 365) generally found inside the ear-lobes and other protected parts of buffaloes, oxen, etc. Among fleas, we have the hen flea (*Echidnophaga gallinaceæ*, W.) a minute flattish creature, found attached in numbers to the diffierent parts of fowls, especially the head ; it is also known to attack man sometimes. (*See* for other fleas and lice under-Chapter Disease carrying insects.)

Ticks and mites.—Ticks and mites are not insects but belong to the group Acarina under the class *Arachnida*. These are like some spiders where the body is not distinctly divided into two or three

* Musca crassirostris according to Patton. (*See* Fig. 25.)

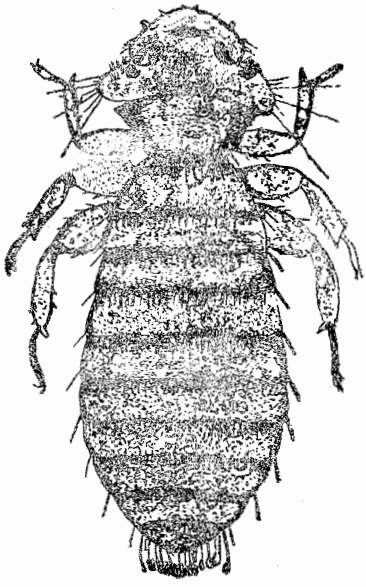

FIG. 364.—A BIRD LOUSE.
(*Menopon.*)

[*After Killop*]

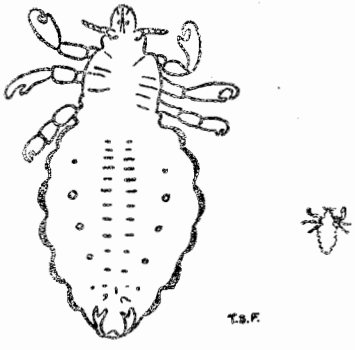

FIG. 365.—CATTLE LOUSE.
(*Haematopinus tuberculatus*, N.)

(*From S.S.J.*)

distinct regions as in insects, and they have eight legs instead of the six found among insects. The mouth parts are constructed for piercing and sucking and sometimes for biting and sucking. The forms of this group attacking cattle and other animals are known as ticks and mites. Excepting some mites which are found on plants most of these creatures are ecto-parasites on higher animal. These very often cause considerable loss to owners of cattle and other domestic animals; some of these creatures are also known as disease carrying forms. These latter includes mites (well-known form is *Psoroptes communis*, F.) causing mange and scabies in dog, sheep, etc., and ticks which include fairly large forms found attacking cattle, dogs and other domestic animals ; chief forms known are the spinose eartick (*Ornithodorus megnini*), Poultry tick (*Argas persicus*, F., fig. 366), Dog ticks (*Rhipicephalus hæmaphysaloides* S., *Boophilus*, etc.), and the Cattle and Horse tick (*Hyalomma ægyptium*, S.).

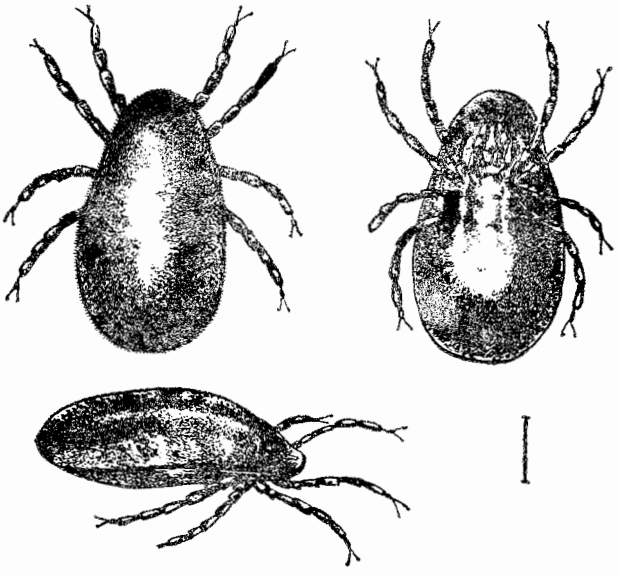

FIG. 366.—PERSIAN CATTLE TICK.
(*Argas persicus*, F.)
(*After Lefroy*)

Control measures.—Except in the case of some specific pests, control measures against the various parasites affecting cattle and domestic animals are practically the same for all of them since the general habits of most of them are more or less similar. As a preventive, cattle and other animals susceptible to these pests should be kept thoroughly clean. They can also be protected in notoriously pest-ridden areas by rubbing their bodies with some oil or other preparations which will keep away the pests, particularly the blood-sucking flies of different kinds. In some cattle-breeding farms in the western countries herds of cattle are periodically

given a wash or " dip " in some preventive solution to guard against all parasites and for this purpose, " dipping vats or tanks " are maintained. Crude oil emulsion is an excellent preparation for periodical washing of cattle in this manner. It is also desirable that stables cattle-yards, sheep pens, poultry houses and other breeding places should be kept thoroughly free from vermin by periodical cleaning and if necessary, washing with some sanitary solution or even by fumigating these places. Nowadays a number of commercial preparations having D.D.T. as one of the main components are put in the market and some of them were found quite effective. It is also the custom in many places to keep under quarantine and watch cattle or sheep freshly introduced from outside the area. Against bot flies of different kinds and allied internal parasites, apart from these external precautions to keep away the fly from laying eggs on the host, the services of veterinarian will have to be secured to administer internal medicines whenever necessary. Readers are requested to refer to veterinary publications for further particulars regarding insect pests of cattle.

CHAPTER XXI.

DISEASE-CARRYING INSECTS.

Under this category it is proposed to deal with such insects which affect the person of the house-holder and cause not only trouble and annoyance but also contribute to the transmission of some well-known diseases. The most important of these are the Housefly, Eyefly, Mosquitoes, Fleas, Sand flies, Lice, Bed bug and the Conenose bug. Some mites can also be included under this category.

The Housefly (*Muscidœ, figs.* 367 *and* 368).—This is one of the most notorious of all household pests all over the world. In South India, this familiar insect is represented by two species (*Musca nebula*, F., and *M. pattoni*, *A.*) ; the life histories of these forms are practically similar. The creature which is about $\frac{1}{4}''$ long is of dirty grey colour with some dark stripes on the thorax and small hairs all over the body. The mouth parts consists of a licking or lapping tube with a broad pad at the tip ; they are not adapted for piercing and sucking blood as in the stable fly (*Stomoxys*). The life history is like all ordinary flies (fig. 367). Small cigar shaped pearl white eggs in batches of over 100 are deposited in fresh manure, night soil or in other decomposing organic matter ; horse dung is found specially attractive for egg laying. Eggs hatch in about a day or two according to variations in temperature. The larvæ are small cream white headless maggots. In a week's time when these maggots reach maturity, they migrate to drier parts like the edge of the manure heap, the surrounding soil or ashes to pupate. The pupæ are small, smooth, brownish seed-like objects. In another week, the adult fly emerges from the puparium. The period of one life cycle from egg to adult occupies about two weeks, though this varies according to weather conditions, being shorter in hot weather and longer in the cold season. During summer, the fly breeds rapidly and multiplies in population. Unlike the biting flies or the mosquito, the housefly is not able to pierce the skin but it causes considerable annoyance by settling upon our bodies and our food-stuffs and contaminating them often with filthy particles from various sources carried in their body hairs, wings, feet, etc. ; in many cases, they also make food-stuffs unwholesome by depositing fly '*specks*' (fœces) and often by themselves dropping into liquids like milk, coffee, etc. Professor Nuttall very graphically explains this matter in the following words : "It should be remembered that a fly may cause relatively gross infection of any food upon which it alights after having fed upon infective substances be they typhoid, cholera or diarrhœa stools. Not only is its exterior contaminated, but its intestine is charged with infective material in concentrated form which may be discharged undigested upon fresh food which it seeks. Consequently the excrement voided by a single fly may contain a greater quantity of the infective agents than, for instance, a sample of infected water. In potential possibilities the droppings of one fly may, in

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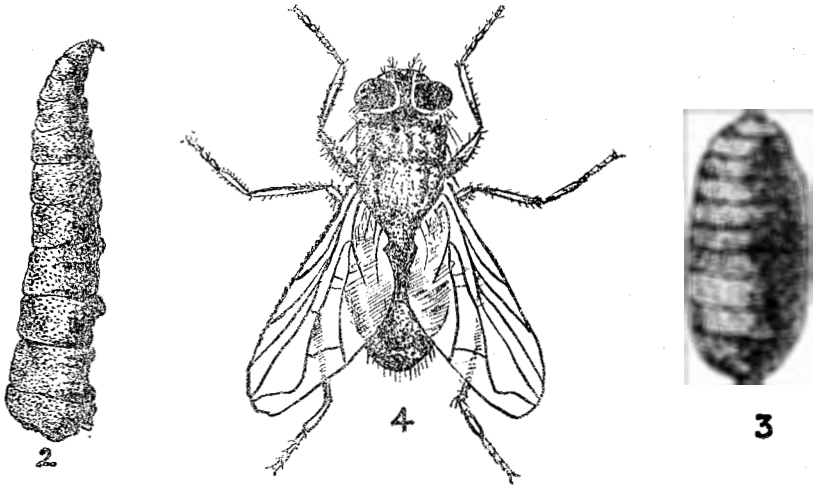


FIG. 367.—HOUSEFLY STAGES.

certain circumstances, weigh in the balance as against buckets of water or milk." So far the fly has been found to be an important agent in the transmission of such nasty diseases as Typhoid fever, Dysentery, Diarrhœa, Tuberculosis and Cholera. It is also charged as being responsible to some extent in the transmission of other diseases like Opthalmia, Frambœsia, Trypanosomiasis, etc.

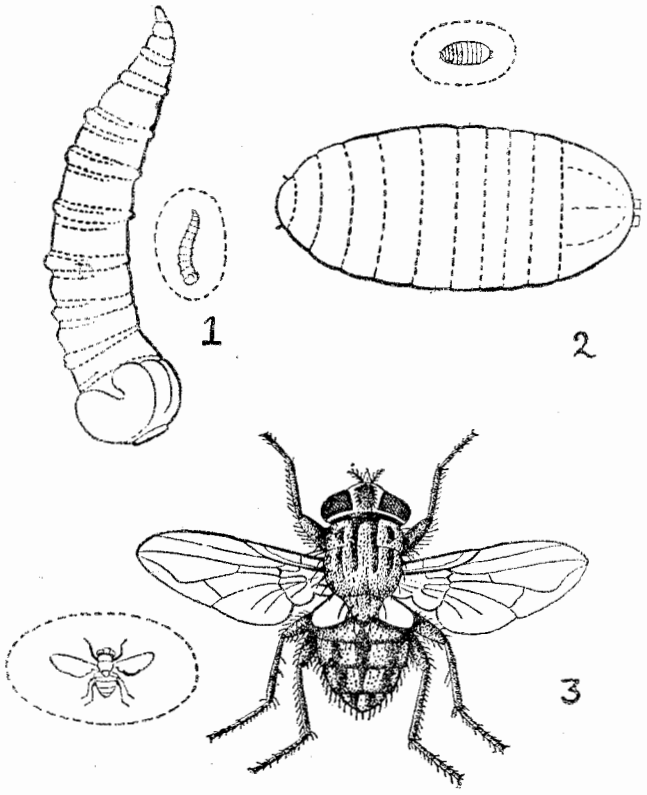


FIG. 368.—A COMMON HOUSEFLY OF SOUTH INDIA.
(*Musca pattoni*, A.)
1 Maggot. **2 Pupa.** 3 Fly. [*From S.S..I.*]

Control measures.—The most effective control measures against the housefly are the proper attention to their breeding places and the prompt disposal of all household rubbish, manure and night soil. As stated above, horse manure has to be particularly attended to as it is a very prolific source of housefly production. In crowded cities, such measures have to be attended to by public bodies by enforcing sanitary rules on householders and by co-operation in various ways. In the way of temporary relief in houses, mechanical devices and traps of different kinds are known such as fly papers, poisoned fly traps, sprays, screens, etc. The fly multiplication is also checked by trapping flies and maggots by the use of fly and maggot traps of different kinds (fig. 369). By means of the former flies are attracted with baits into a maze like enclosure and by the latter the maggots are driven to destruction before they pupate. These maggot traps are constructed by taking advantage of the migratory habits of the fly maggot before pupation. Such a trap usually consists of a wooden platform placed over a basin containing some water. The manure is heaped on the platform and fullgrown

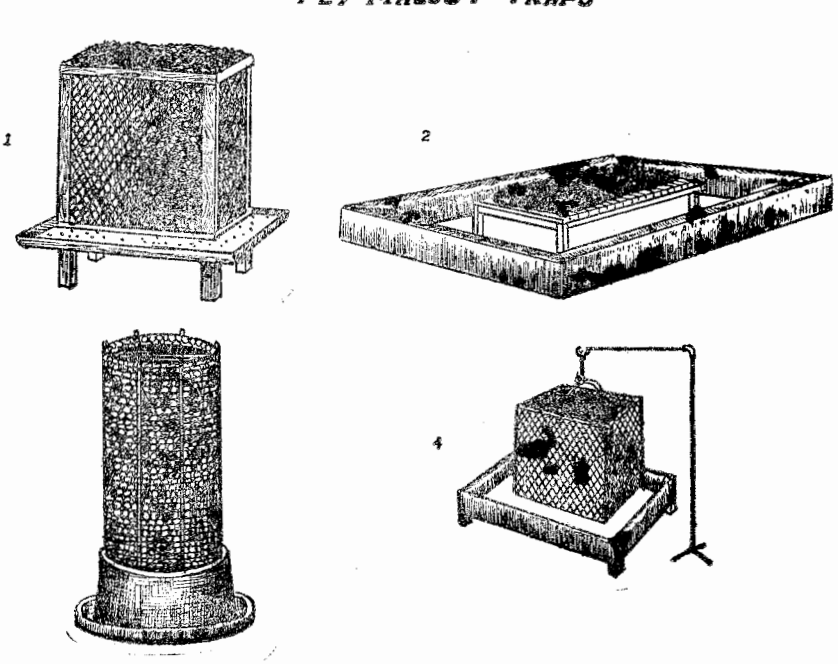


FIG. 369.—MAGGOT TRAPS OF DIFFERENT KINDS.

maggots from it migrating in search of drier soil to pupate fall into the water and get drowned. It is important that the manure should be moistened thoroughly by sprinkling water on it. A trap can be devised on this plan on a smaller or a larger scale according to needs. There exists plenty of literature on this subject and we would refer our readers to them for further details.

The Eye fly (*Choloropidae*).—This is a minute bluish black fly (*Siphonella funicola*, D) in general build like a small housefly with which householders are familiar. It generally settles on the face, especially on the corners of the eyes of persons with eye complaints and causes a good deal of annoyance. These have the habit of attaching themselves in swarms on odd ropes and threads hanging from roofs, etc., especially in thatched sheds in damp warm places. Some common eye complaints are believed to be transmitted by this fly (fig. 370).

Mosquitoes (*Culicidae*).—These are well-known insects very familiar to us and directly more annoying than houseflies as they are able to pierce the skin and suck blood. These are delicate long limbed active creatures belonging to the same order as the house fly (Diptera). A special characteristic of these insects is that the wings, especially along the veins and the body are covered with thin minute scales as in butterflies. The mouth parts are adapted for sucking;

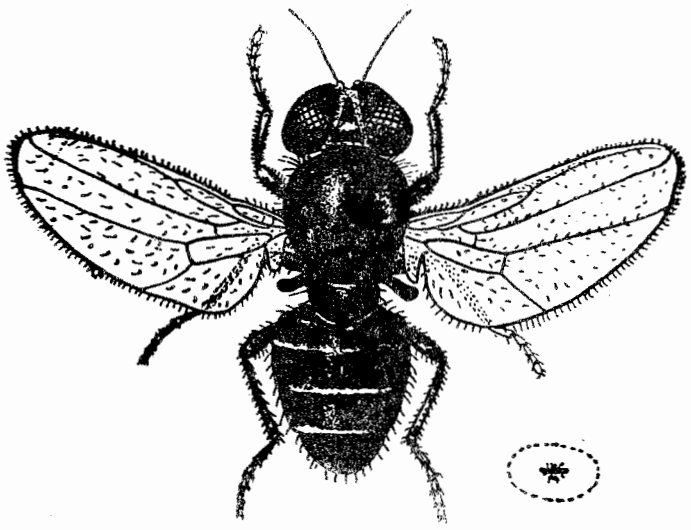


FIG. 370.—THE EYE FLY.
(*Siphonella funicola*, M.)

they are specially well-developed for blood sucking in the females. Their larvæ known as "*wrigglers*" develop in water and their pupæ which are also aquatic move about actively (fig. 373). Mosquitoes are generally divided into two groups—the *Culicines and Anophelines*; the differentiating characters relate to structural features and especially to the general features and habits of the developing stages in the two groups. The differences may be shown in the following form :—

Group.	Eggs.	Larvæ.	Adults.
Culicine ..	Laid in rafts each containing several eggs.	Remain under water with the head downwards and anal tip towards surface.	Wings plain; palpi short, never as long as proboscis. When at rest, head and body forming an angle (see fig. 372) scutellum with three groups of hairs.
Anopheline ..	Laid singly ..	Remain parallel to and just under the surface of water.	Palpi long; those of males and females about same length as the proboscis in Indian forms. Wings spotted. When at rest, head and body in a straight line. Scutellum without three groups of hairs (fig. 371).

Both these groups include representatives which are both troublesome household pests as well as disease carriers. In the Culicinæ group are found the common household mosquitoes of the general

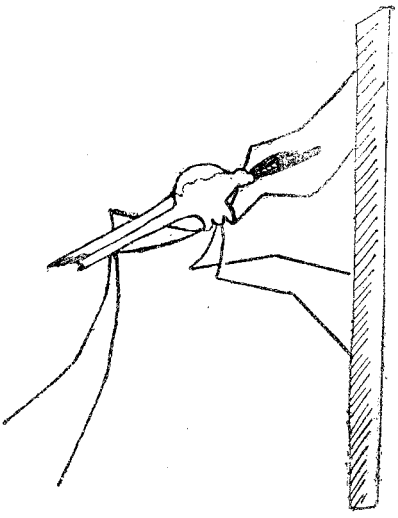


FIG. 371.—RESTING POSTURE OF ANOPHELES MOSQUITO. 1 [*From S.S.I.*]

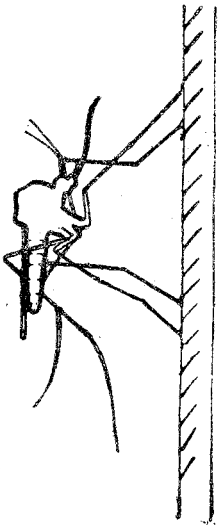


FIG. 372.—RESTING POSTURE OF CULEX MOSQUITO. 2 *From S.S.I.*]

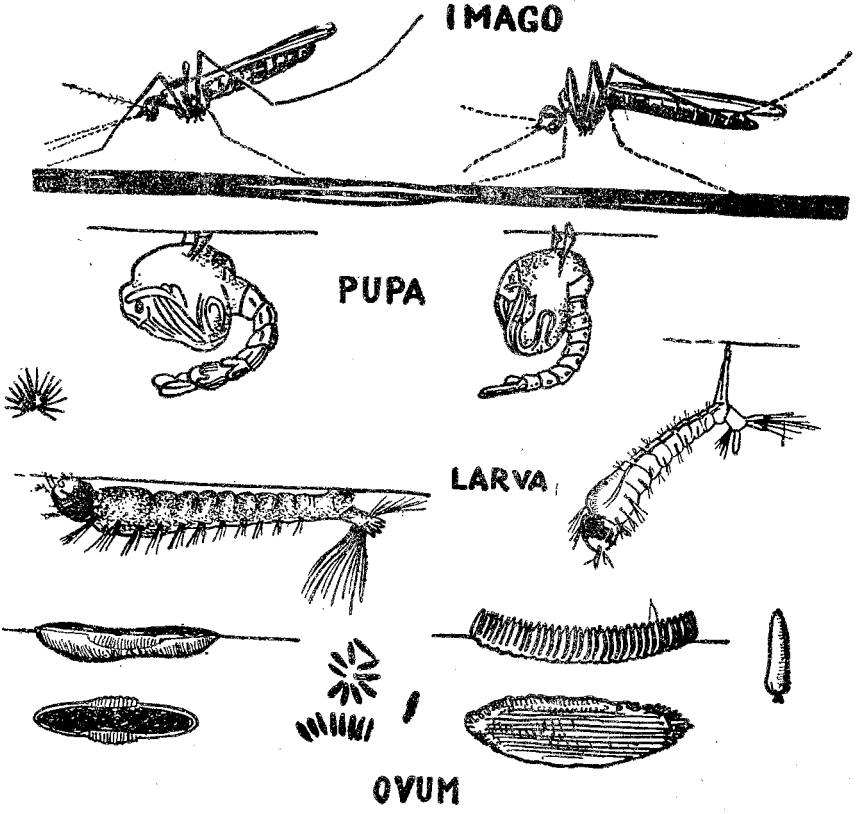


FIG. 373.—MOSQUITO LIFE HISTORY.
1 Malarial Mosquito. 2 Ordinary Mosquito.

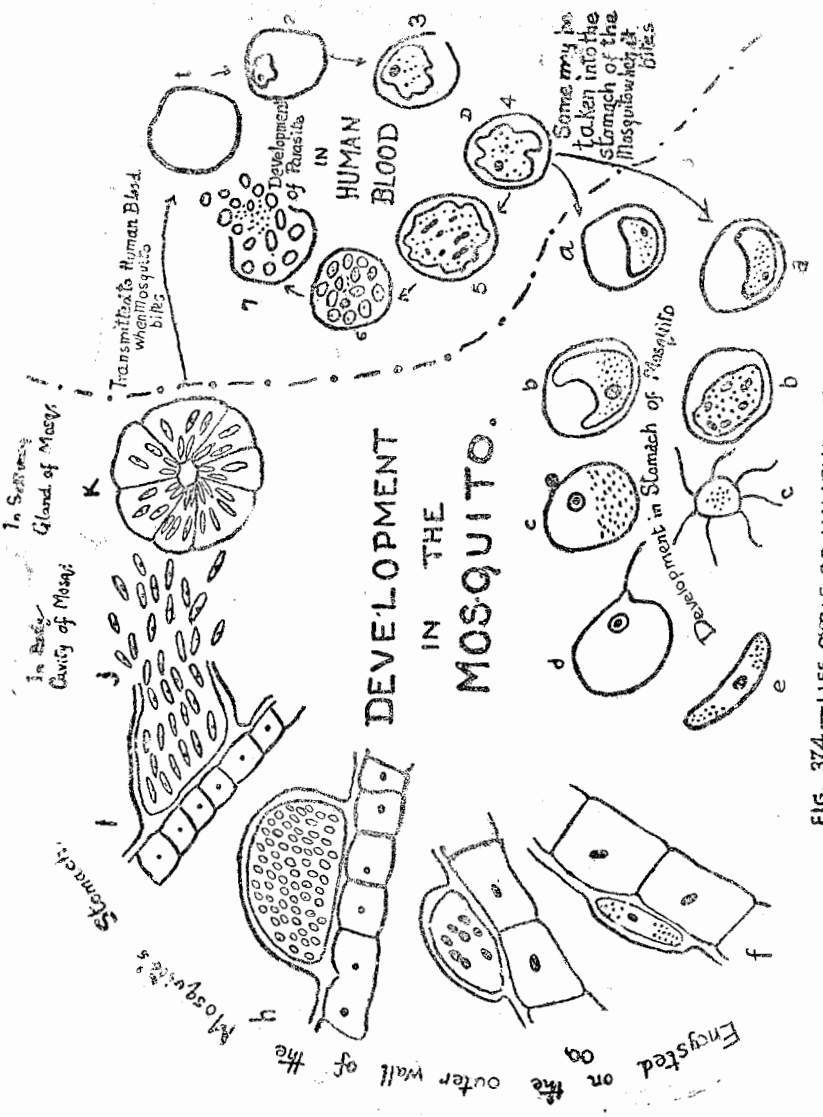

DEVELOPMENT
IN THE
MOSQUITO.
Development of Parasite IN HUMAN BLOOD
Some may be taken into the Stomach of the Mosquito when it bites
Transmitted to Human Blood when Mosquito bites
In Salivary Gland of Mosq.
In Body Cavity of Mosq.
Development in Stomach of Mosquito
Encysted on the outer wall of the Stomach
Myriads of Sporozoites

FIG. 374.—LIFE CYCLE OF MALARIAL GERM.

[*From S.S.I.*]

Culex (*C. fatigans* W.—being the commonest in South India fig. 375) and *Aedes* (including *A. fasciata* F.—the silver spotted or tiger mosquito, fig. 376). The anophelines include many forms which

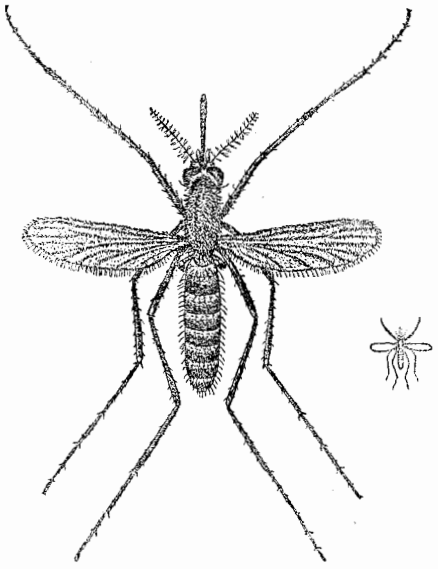


FIG. 375.—COMMON HOUSE MOSQUITO (*Culex fatigans*, W.) [*After Patton*]

FIG. 376.—THE SILVER SPOTTED MOSQUITO. (*Aedes fasciata*, F.) [*After Goeldi*]

are concerned in the transmission of the malarial fever germ (three of the commonest South Indian forms are *Anopheles culicifacies*, G., *A. fluviatilis*, J., and *A. stephensi*, L.). The malarial germ undergoes changes both in man and the mosquito (fig. 374). Some species of *Culex* have been found to be transmitters of diseases like Filariasis and Dengue. Details regarding such diseases and the part played by insects will be found in numerous publications on Medical Entomology and Public Health.

Mosquito control.—As in the case of the housefly, radical cure depends on the proper attention paid to mosquito breeding spots such as ponds and streams of stagnant water, ill-drained swamps, gutters and all situations in houses, latrines, gardens, etc., where water is allowed to stagnate in various ways. Such accumulations of water are generally treated by oiling the surface to kill the aquatic larvæ, by filling up swamps with soil, by use of larvicides of different kinds and by arranging proper drainage of stagnating sewers and channels. As temporary measures of relief against mosquito bites the use of mosquito netting, traps, wire gauze screens and application of mosquito repellent drugs like citronella oil (see Appendix III) are well-known. Permanent relief from mosquitoes in any locality can be obtained only by radical measures carried

out with the proper co-operation of all the inhabitants in any locality. The control of mosquitoes, flies and other disease carriers has practically been revolutionised since the discovery of the wonder insecticide—D.D.T. Places which were till recently uninhabitable due to the prevalence of malaria have been converted into flourishing estates and plantations as a result of the intensive mosquito control work by the Anti-malarial department.

Fleas (*Pulicidæ*).—A reference has already been made to these insects under pests of cattle (page 400). These are small active wingless insects with the body laterally compressed and having stout hind legs adapted for leaping. In size, they are about 1/12 or 1/10 of an inch. The mouth parts are piercing tubes and adapted for sucking blood from warm blooded animals. Eggs are generally laid loose by the mother flea on the host, or on dust, excrement, etc., in its haunts. The larvæ are whitish slender maggots which live on the organic particles generally found under dirty carpets, matting, unclean corners of rooms and in the sheds of domestic animals like rabbits, pigs, dogs, etc. When full fed the larva changes into a pupa inside a pale silken cocoon and in about a fortnight the adult flea emerges out of it. Different species of fleas generally live on different kinds of hosts though some live on more than one kind of host. Some of the well known forms are the human flea (*Pulex irritans*, L.), the rat flea (*Xenopsylla cheopis*, R., fig. 377) and the dog and cat fleas (*Ctenocephalus felis*, B. fig. 378 and *C. canis*, C.). Fleas are troublesome and disgusting not only because of the pain and discomfort caused by their bites but also because some of them are disease carriers. The rat flea (*X. cheopis*, R.) has been found

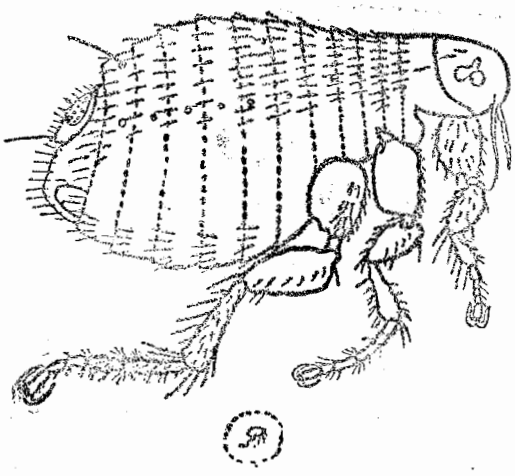


FIG. 377.—THE RAT FLEA.
(*Xenopsylla cheopis*, R.)

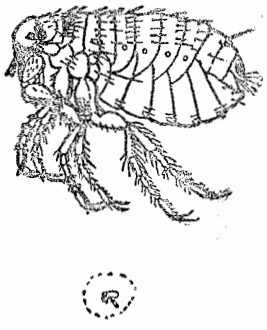


FIG. 378.—THE CAT FLEA.
(*Ctenocephalus felis*, B.)
[*From S.S.I.*]

to be the transmitter of the bubonic plague bacillus (*Bacillus pestis*) from rat to man. In some of the hill stations fleas often cause considerable annoyance in houses during certain seasons.

The best remedy against fleas is to attend to the sources of infestation, namely, rats, cats, dogs, etc. Destruction of rats, proper attention to the healthy condition of cats and dogs, proper dusting of carpets and mattings, and thorough washing with some sanitary fluid of the rooms haunted by fleas will control them easily.

Sand and Moth flies (*Psychodidæ*).—Closely allied to the mosquitoes but smaller in size are these small hairy moth like insects which are common in different parts of South India; they are blood suckers and even penetrate into mosquito curtains; they have a partiality to attack toes, knuckles, etc., and cause severe irritation. The common South Indian form is (*Phlebotomus minutus*, R., fig. 379.) These creatures are suspected as carriers of what is known as "Sandfly fever." A small midge (*Culicoides keifferi*, P.) of the family Chironomidæ also attacks cattle and man in parts of South India and causes annoyance.

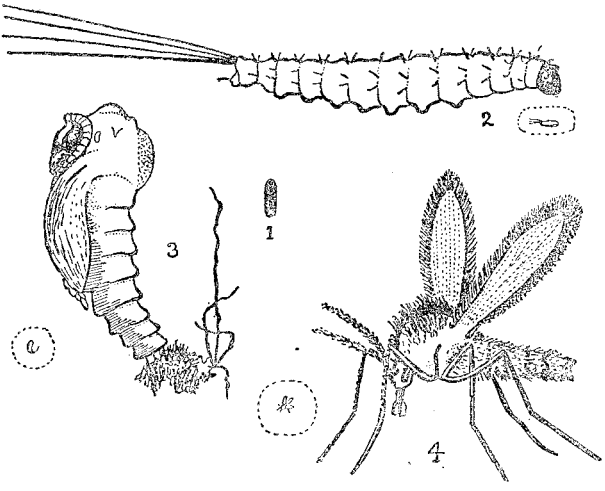


FIG. 379.—SAND FLY AND STAGES.
(*Phlebotomus minutus*, R.)
[*After Howlett*]

Lice (*Pediculidæ*).—Small greyish wingless flattened insects found on the hair and body of unclean human beings. In bad nfestations the hairs show rows of eggs (*nits*) glued to them. In habits, they are blood sucking forms and some of them cause not only itching and irritation, but are also responsible for the transmission of some diseases. Three forms have been noted to affect man,

viz., the head louse (*Pediculus humanus, N.*), the body louse (*Pediculus corporis*, D.G.) and the crab louse (*Phthirius pubis*, L.), figs. 380, 381 and 382. The two former generally remain on the head and body while the last one known from its peculiar shape and form as the " crab louse " is found in the pubic region. Such diseases known as " Relapsing fever " " Typhus " and " Trench fever " are known to be transmitted by these lice. Thorough cleanliness of one's body by regular baths, sufficient attention to clean clothings and avoiding contact with infested people will control lice. In schools, dormitories and armies, co-operative action has to be taken to remove lice infection.

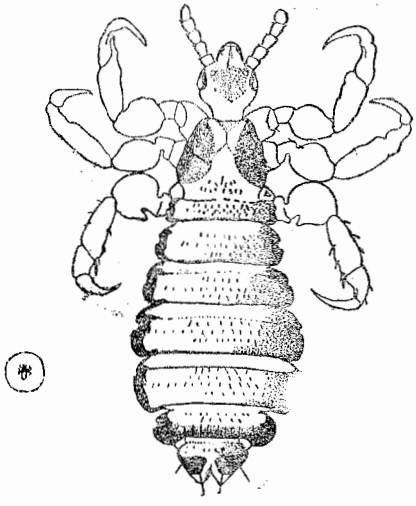


FIG. 380.—THE HEAD LOUSE.
(*Pediculus humanus* N.)
[*From S.S.I.*]

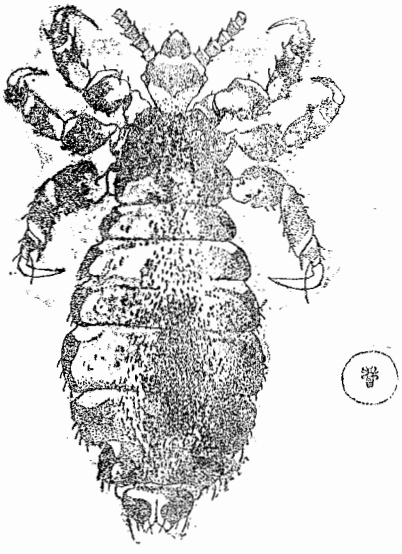


FIG. 381.—THE BODY LOUSE.
(*Pediculus corporus, dG.*)
[*From S.S.I.*]

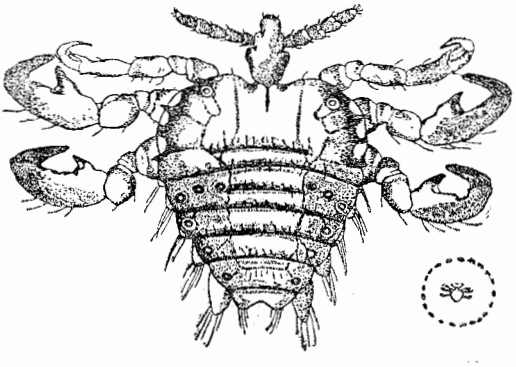


FIG. 382.—THE CRAB LOUSE.
(*Phthirius pubis*, L.) [*From S.S.I.*]

The Bed bug (*Cimicidæ*).—This is a small oval flattened reddish brown insect measuring about $\frac{1}{4}$ inch in length. Its mouth part consists of a sharp proboscis adapted for piercing and sucking and it is wingless. Conspicuous yellowish white eggs are laid in the haunts of the creature and the young ones hatching out resemble the parent except in size and color. The bugs generally remain in

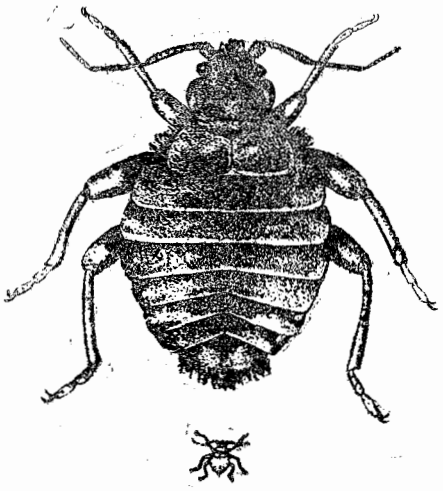


FIG. 383.—THE BED BUG.
(*Cimex rotundatus*, S.)

[*From S.S.I*]

cracks and crevices of wood work and furniture in dwellings and public conveyances; they are active during the night hiding during the day time, and often migrate from room to room. They feed on mammalian blood by piercing the skin, causing pain and even inflammation in some men and possess a disgusting odor. The common South Indian form is the tropical bed bug (*Cimex rotundatus*, S., fig. 383). It is believed that the bed bug acts as a transmitting agent of 'Kala-azaar' (a very serious protozoal disease found in some parts of India) and Relapsing fever (Spirochaetosis). Control measures in this case should be directed to the cleanliness of rooms, mattresses, furniture, etc., by proper repairs, cleaning and the necessary precautions to prevent entrance of bugs from infested things like beddings and luggage brought after a journey, etc. Badly infested furniture and rooms may be made bug-free by washing with insecticides which will penetrate the crevices and cracks in furniture, walls, etc., or even by fumigation.

The cone nose bug (*Reduviidæ*).—This is a large sized, $\frac{1}{2}$ to $\frac{3}{4}$ inch long dark brown active bug (*Conorhinus rubrofaciatus*, G., fig. 384), sometimes found in houses. It belongs to the family of assasin bugs and is suspected to be a disease carrier, since in Brazil a closely related form (*Conorhinus megistus*, B.) has been found to be the host of a well-known human disease (*Trypanosomiasis*).

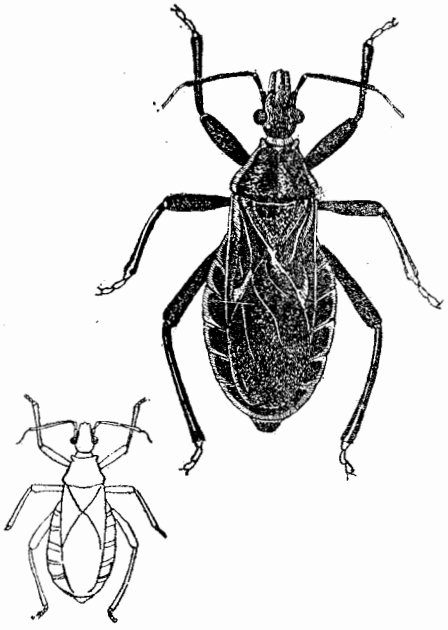


FIG. 384.—THE CONE NOSE BUG.
(*Conorhinus rubrofasciatus*, dG.)

[*From S.S.I.*]

In dealing with the subject of insects and diseases the following point is worth noting in connexion with the methods of disease infection. In cases like the mosquito, bed bug, fever ticks, etc., the disease germ actually gets into the body of the insect vector, undergoes certain changes in the insect and is then transmitted to the body of human beings and higher animals (as in the case of malaria, trypanosomiasis, etc.); on the other hand, in the case of the insects like the housefly, the parasite is merely carried on or inside the body of the insect and deposited on the human being without the disease germ undergoing any change (as in cholera, typhoid, etc.). This latter phenomenon where the insect merely performs the function of a porter or messenger is termed "*Myiasis*" and this term is also used to include the spread of bacteria, eggs

of intestinal worms, etc., and the disturbance caused by insect larvæ in different parts of the bodies of higher animals. Cases of such myiasis are found associated with screw worm flies, blue bottle flies, flesh flies, etc., which attack open sores and wounds in cattle and even in men, and cause very serious bodily disturbances.

Mites on man.—Just as in the case of cattle, certain species of mites (non-insects) cause complaints known as "*acariasis*" in human beings also. These include small forms attacking the human skin such as the itch mite (*Sarcoptes scabici var hominis*, R.) which is very closely allied to the sheep and goat mange mites, and which mainly attacks the fingers, knee and elbow and causes insufferable itching, the follicle mite (*Demodex folliculorum*, S.) found attached to the hair follicles in man sometimes giving rise to inflammation, the straw or grain mite (*Peduculoides ventricosus*, N.) which attacks people handling grains, straw, etc., and often causes itching and dermatitis and the tiry mite (*Tyroglyphus longior*, G.) found among persons dealing in copra, dried nuts, cereals, etc., and causing "*copra or grocer's itch.*"

As stated once before, only the more important facts in connexion with the insect pests affecting cattle and those concerned with the transmission of diseases have been touched upon in these chapters and readers are therefore referred to publications on Veterinary and Medical Entomology for further details.

CHAPTER XXII.

Beneficial Insects.

Productive insects—(Honey-bees—Silkworms—Lac insect)—Helpful insects—(Parasites, Predators, Weed-killers, etc.)

In the foregoing chapters we saw how insects of various kinds cause trouble to man in different ways and bring about damage and loss. We shall now turn to the other side of the picture—a pleasanter but little recognized one, viz., the activities of many insects which benefit man in various ways. Being familiar only with the more obvious injuries caused by insects, many of our farmers and laymen are not sufficiently aware of this favourable aspect of insect activities. This class of insects which are beneficial can be conveniently divided into two main groups according to the nature of the benefit man derives from each, viz., *Productive and Helpful* insects.

Productive Insects.

This group includes a few important forms which, in the course of their life activities, produce certain substances which are used by man in different ways. Of course, such insects do not produce those substances, with the idea of benefiting man; but he appropriates what is intended by nature for the use of the insects themselves. The most important of these insect products are Honey, Silk and Lac—produced by the Honey-bees, Silkworms and Lac-insect respectively.

Bees.

Though popularly the term ' Bee' has been understood to refer to the domesticated honey-bee, because of its long and intimate association with man, this term can be applied without mistake to a number of other insects. Familar examples of bees other than honey bees are the carpenter bees and the leaf-cutting bees. The life history and habits of most bees are similar; they are mostly vegetable feeders and generally live on the pollen and nectar of flowers. All bees pass through a complete metamorphosis as in beetles and butterflies; the larvæ are helpless and have to be fed. In India we have four forms, which are typical honey-bees, viz., the three stinging bees (under *Apis*) and the stingless Dammar bee *Melipona* [fig. 385 (5)]. All these honey-bees are social insects and live in colonies like ants and white ants and exhibit remarkable social instincts and division of labour. The three species of *Apis* and their fundamental features are—

(1) *Apis dorsata, F.* [*fig.* 385 (6)].—The rock bee: This is the largest of the Indian honey-bees and produces plenty of honey; it builds large open single combs which may often be four feet long on tall forest trees, along sides of precipitous cliffs and occasionally on the walls and other parts of buildings. The honey got from these

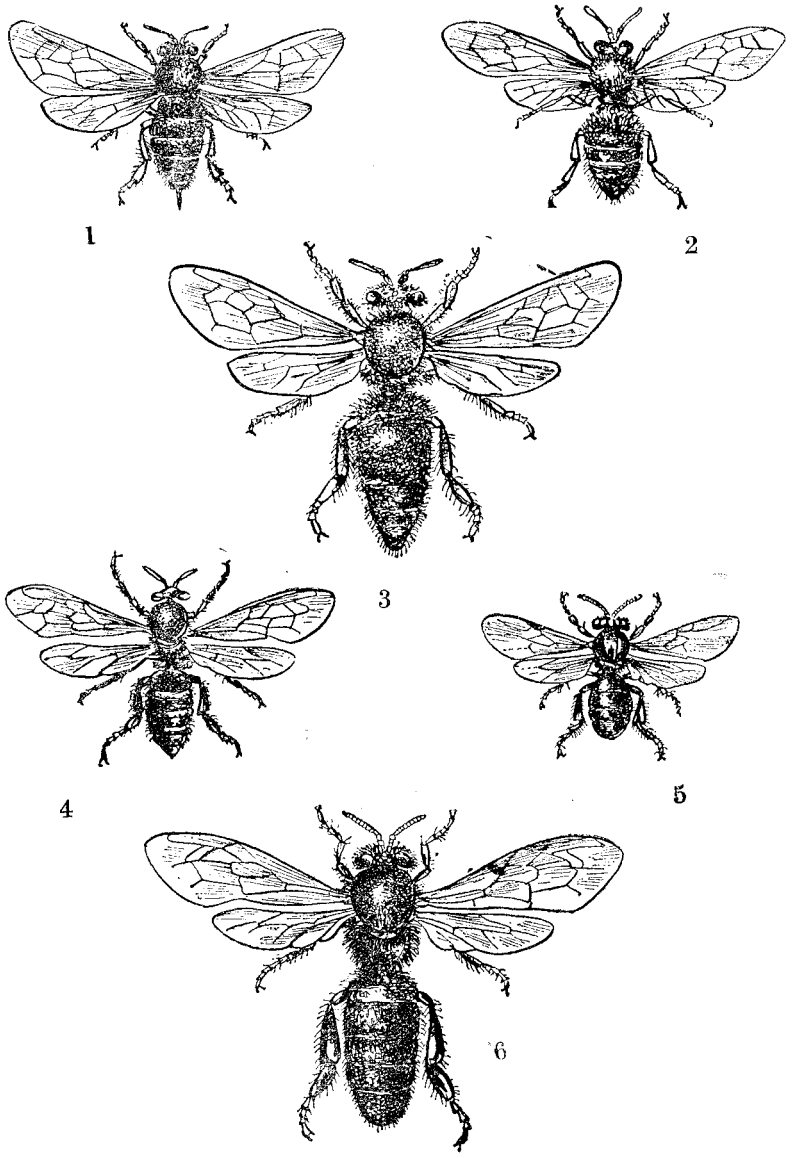


FIG. 385.—INDIAN HONEY BEES.

1 *Apis indica*-worker.
2 *Apis indica*-drone.
3 *Apis indica*-queen.
4 *Apis florea*-worker.
5 Melipona-worker.
6 Apis dorsata-worker.

[*From Pusa Bulletin*]

hives forms the bulk of the material collected by hill people and sold in our bazaars all over India. The irritable and ferocious temper of this bee, its peculiar hives and its confirmed nomadic habit of deserting its hives frequently have made it impossible to domesticate it.

(2) *Apis florea*, F. [*fig.* 385 (4)].—This is the smallest of the three species and is known as the little bee. This also builds single combs which are however, very small and often found hanging from bushes and corners of roofs; each comb usually gives but a few ounces of honey.

(3) *Apis indica*, F. [*fig.* 385 (1–3).—This is the common Indian honey bee found both in the plains and forests all over India. In size, this is larger than *florea* and smaller than *dorsata*. This bee, unlike the other two, builds several parallel combs, generally in hollows of trees, caverns in rocks, on the walls inside wells, caves and similar protected spots. This is the typical Indian honey bee and the only one which has so far been found to be capable of domestication. In the different hill tracts of South India, the common bee found is a dark race of this *indica*. The only other known species of *Apis*, besides these three Indian forms, is the European bee—*A. mellifica*, L. (*fig.* 386)—which is the honey bee domesticated

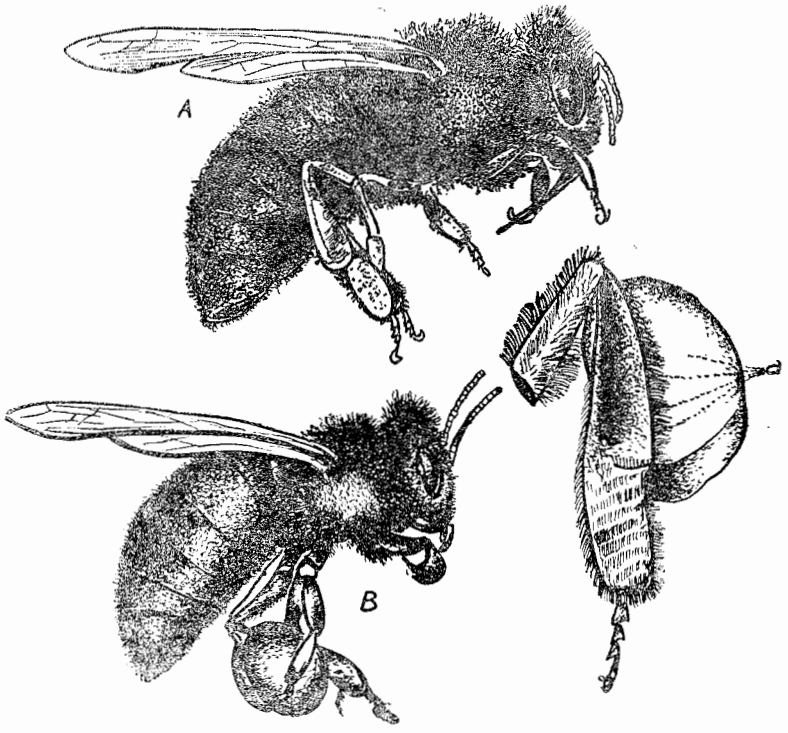


FIG. 386.—BEE SHOWING POLLEN GATHERING.
(*Apis mellifica*, L.)
[*From Wheeler*.

and extensivley reared all over Europe and America, and this latter species, except in a few minor features, is very closely similar to *indica* in structure and habits.

The members of a bee colony.—In an average thriving colony of the Indian bee (*indica*) there is generally found a population of about forty to fifty thousand bees. This large number is, however, made up of three different kinds of individuals inhabiting the colony. These are the *Workers*, the *Drones* and the *Queen*—the workers making up the great bulk of the population (over 90 per cent). The *Worker* bee is an immature female, smaller in size than the queen or the drone ; on her devolve most of the important domestic duties of the colony such as gathering of honey and pollen, building of the combs, rearing the brood, defending colony from enemies, attending on the queen and keeping the hive sanitary and warm. To perform these duties satisfactorily, the workers are also provided with the necessary structural adaptations. The tongue is comparatively long, the hind legs have basket like hairy structures (" *pollen baskets* ") to collect pollen (see fig. 386), the abdomen has glands to secrete wax (see fig. 387) which is the material used for comb building and they have a powerful sting at the tail end of the body for defence, fig. 35. The *Drone* is the male bee and comparatively heavier built than the worker ; its eyes are very large and meet at the top of the

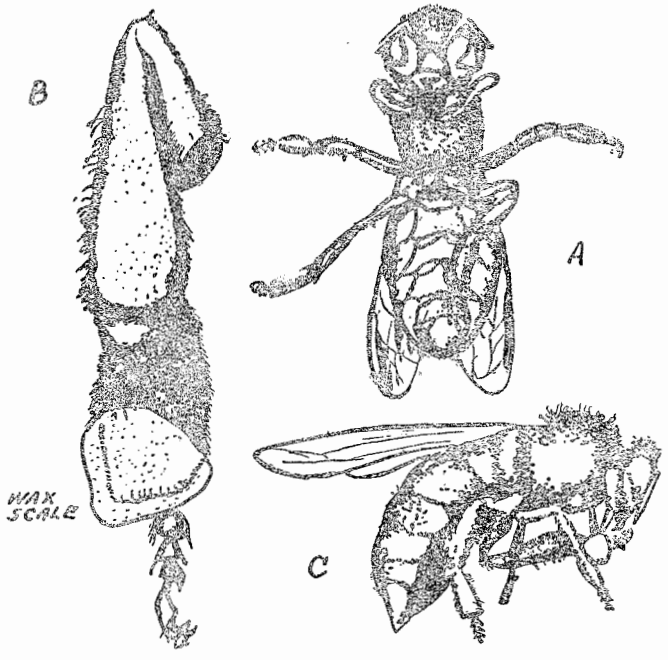


FIG. 387.—BEE SHOWING WAX SCALES.
(*Apis mellifica*, L.)
[*From Wheeler*]

head. It has no pollen basket, wax producing structures or a sting. The duty of the drone simply consists in acting as the husband of the virgin female bees. Very few drones are generaly found in a healthy and vigorous colony, and at times there may be no drones in the colony at all. The *Queen*—In every colony there is usually found only one mother insect or queen which is a mature female, bigger and longer than the worker, she has no pollen baskets or wax plates but has a conspicuous combined sting and ovipositor, the latter for depositing eggs, fig. 17. The only function of the queen in a colony is to lay eggs and thereby add to the population of the colony and keep it strong. This egg-laying machine is known to deposit two or three thousand eggs a day and under satisfactory conditions lives for two or three years. Various and marvellous are the numerous activities of these bees, especially of the workers which go to regulate and maintain the multifarious normal and abnormal needs and the domestic economy of a colony.

The Bee-hive.—As stated at the beginning, the common Indian honey bee in its natural haunts lives in what are called *hives* made of combs constructed by members of the colony in well protected places. Each hive is made up of a number of combs generally remaining parallel to each other. The combs, which are made of wax, are divided up into thousands of hexagonal cells, each comb having a double set of them, one on each surface ; and these cells serve as receptacles for the storage of honey and pollen and as chambers for the developing brood. The bee hive, with its remarkable architectural and economic arrangement, is one of the wonders of the insect world. Adult bees of all the three different kinds when at home simply remain clustering to and moving along the surface of the combs and do not have any special lodgings, Usually the cells in the upper part of the combs are utilized for the storage of honey and the lower ones are utilized for brood rearing. Wax which is the material with which these combs are built is a secretion which exudes as a semi-fluid substance, through some of the ventral plates of the abdomen of the workers ; this solidifies into the plastic wax so ideal a material for constructing the comb. The best stone mason or brick-layer will simply marvel at the way in which the bee removes its wax from its belly, kneads it with the help of its mouth parts and uses it for comb building. During the busy season when the honey cells have to be built at a rapid rate workers gorge themselves with honey and this stimulates wax production. It is believed that to produce a pound of wax, bees have to consume about 10 to 15 lb. of honey ; as such, comb building and brood rearing go on vigorously when there is plenty of honey available.

Food of the Bee.—The food of bees as stated before, consists usually of nectar and pollen from flowers. The adult bees chiefly feed on honey while the young ones have to be fed mainly on pollen, although it is often mixed with honey and water forming a paste called " *bee bread* ". The developing grub in each of the brood cells

is unable to find its food and has, therefore, to be fed with these materials by the nursing workers of the colony until they are full grown and about to pupate. Since the food of bees in all stages consists of materials from flowers of different kinds they generally thrive well in jungles, flower gardens and orchards, where flowers of various kinds form their pasturage for both nectar and pollen. Occasionally, however, bees have been noted lapping up the honey dew of some plant bugs and it is said that they also seek sugar in other places than flowers.

Honey.—The honey we get from bee hives is not the actual nectar which the insects collect from various flowers. This nectar is swallowed by the creature and afterwards regurgitated into the honey cell. In the honey stomach of the bee in which the nectar remains before regurgitation, certain chemical changes take place and it is this changed material which is called honey.

Enemies of Bees and Bee diseases.—The Indian bee, unlike the European *mellifica* is so far free from the two notorious bee diseases, —"*the Isle of White disease*" and "*Foul brood.*" In the shape of active enemies we have the Bee eater among birds; but it is among insects we come across some of their dreadful enemies. A few years ago, the author discovered in the Bababuddin hills in Mysore, a wasp which behaves as a typical bee hunter (*Philanthus ramakrishnae*, T.)—attacking and carrying away bees [fig. 388 (*a*)]. Some of the common hornets *Vespa spp.* [fig. 388 (*b*)] also occasionally attack them. Another wasp (*Palarus orientalis*, K) has also been noted as a bee hunter at Coimbatore. The common hawk moth (*Acherontia styx*) visits the hives and feeds on the stored honey. An inveterate pest of the bee hive is the wax caterpillar (*Galleria melonella*, L.) which often devours the wax combs and causes very serious damage especially in weak colonies (fig. 389). The other enemies of bees are miscellaneous animals of different kinds like the bee eater bird, bears, etc., which rob them of their provisions; under this category of course, comes *man*. The workers that defend the colony from such robbers and trespassers have, of course, their defensive organ in the shape of the poison inoculating sting.

Bees and man.—Man's association with the honey bee dates from time immemorial and the primary object of this relation has evidently been to take advantage of its labours and appropriate the honey and wax for his use. The methods generally adopted by hill men to get the honey are crude, wasteful and barbarous and these apply to gathering of honey from both the rock bees (*dorsata*) and the common bee (*indica*). During nights when the bees are inactive and generally remain clustered on the surface of the hive, burning torches are applied to the hive; and in this process, most of the bees are killed or disabled, The combs are removed, cut into pieces, then pressed and squeezed with the hands and the juice thus obtained is the honey we usually get. Any one with a smattering of insect lore can easily form an idea as to what the component of this liquid are and the degree of its purity.

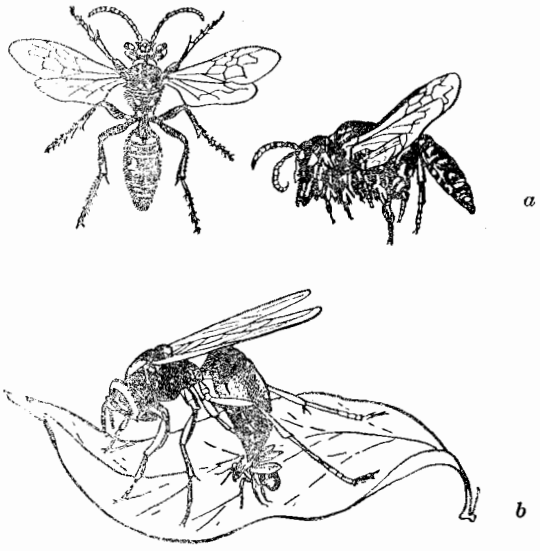
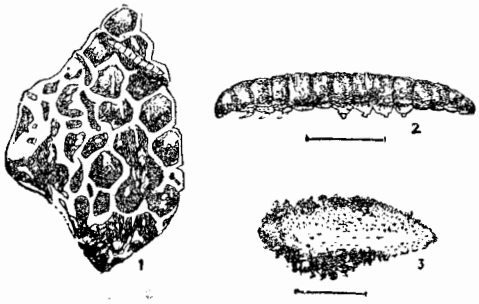


FIG. 388.— BEE ENEMIES.

a Bee hunter wasp (*Philanthus ramakrishnae*, T.) *b* Hornet—(*Vespa cincta*, *F*).



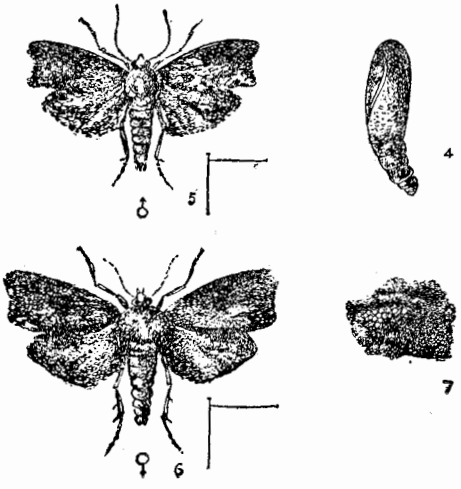


FIG. 389 —THE WAX MOTH-STAGES AND DAMAGED COMB. (*Galleria melonella*, L.)

[*From Pusa Plate*]

In addition to honey, it contains, among other things, the body juices of the developing grubs in the brood cells, lumps of pollen and pieces of wax from the crushed combs. This stuff constitutes the great bulk of what we get from our bazaar grocers as pure honey, though there are worse substitutes often sold as honey. Since the introduction of different kinds of artificial hives with movable frames, fig, 390, the crude methods of honey gathering have almost disappeared in the western countries.

The possibilities of rearing the Indian bee on economic lines have been under intensive study for the past two decades. Appliances and manipulations were either adapted or devised for domesticating this bee and its response also has been satisfactory. A good deal of propaganda is being done to popularise this industry among the rural population and the public are fast realising its importance as a paying proposition, apart from the invaluable benefit accrued by the cross pollination effect by the bees in flowers. Number of apiaries have sprung up in different parts of the State and the industry may now be said to have established itself on a sound basis as a profitable spare time hobby.

Details regarding these methods may be found in special publications on this subject.

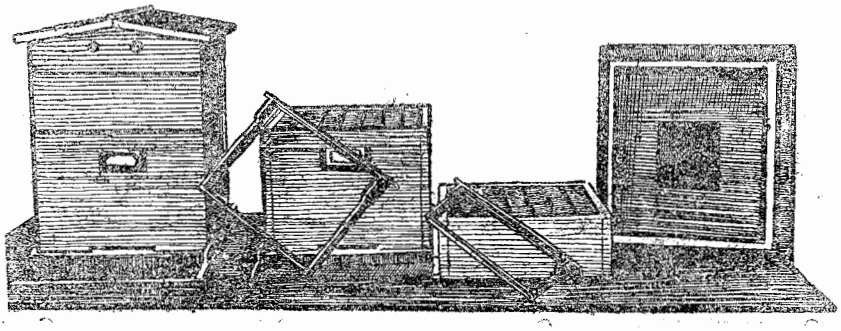


FIG. 390.—A. MODERN BEE HIVE AND PARTS.
a Hive. *b*. Brood chamber. *c* Super. *d* Roof.

SILKWORMS.*

Silk is another very valuable product man gets from the insect world. It is a secretion in the form of a fine thread produced by various insects, especially by the larval forms te prepare the cocoon for the pupa ; even some spiders produce silk for constructing their webs. Among insects, cocoons of silk often mixed with other materials are found made by beetles, wasp and many caterpillars. In India, the silk of commerce is, however, produced only by a few caterpillars belonging to the two families of moths—the *Bombycidae* and the *Saturnidae*. The former includes the

*The author's papers on Silkworms (1916 and 1932) may be consulted.

silkworm *par excellence*, viz., the mulberry worm (*Bombyx mori*, F., fig. 391), and the latter includes the Tassar (*Antherea paphia*, B,) and the Eri (*Attacus ricini*, B.) worms. In all these cases, the useful product silk is obtained from the cocoons produced by the different caterpillars.

The mulberry silkworm (fig. 391).—This is a completely domesticated insect and is never found wild. The type of this worm is the univoltine variety (*B.mori*) extensively cultivated all over the world. The South Indian mulberry silkworm is a variety of the same (*Bombyx mori var meridionalis*) and is a polyvoltine (passing through many broods in the year) race. In South India, it is

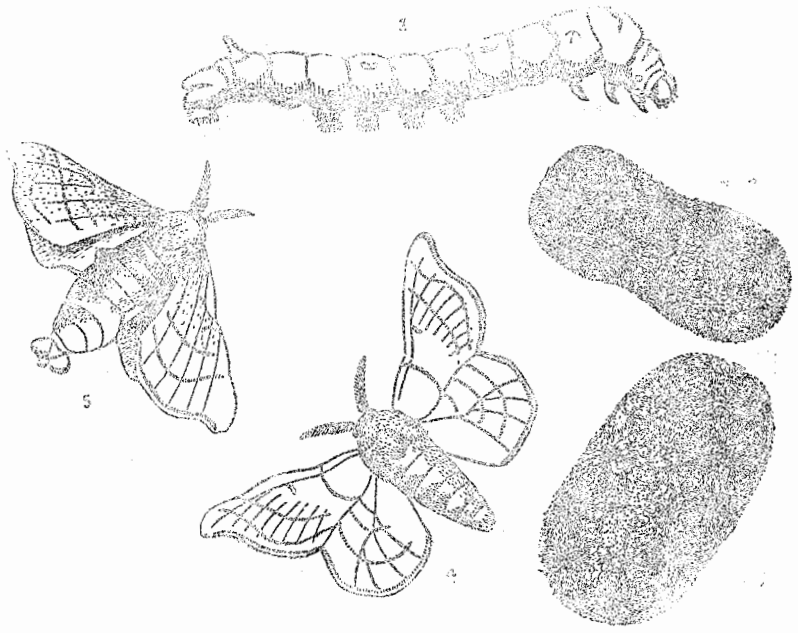


FIG. 391.—THE MULBERRY SILK WORM STAGES.
(*Bombyx mori*, F.)
1 Worm. 2 & 3 Cocoons. 4 & 5 Moths.
[*From I.M. Notes*]

reared on a commercial scale chiefly in parts of Mysore, in the Kollegal taluk of the Coimbatore district and the small Zamindari of Berigai in North Salem. The life history and habits of this insect are practically similar to the European silkworm except that the latter passes through only one brood in the year—the insect hibernating in the egg stage for several months in the year. The adult insect is a pale cream white medium-sized moth which very rarely flies, though provided with wings. The female insect lays numerous eggs which are whitish and seed-like. The caterpillar feeds on the leaves of the mulberry plant and undergoes four moults before pupation. A full-fed caterpillar is elongate and cylindric with a small dorsal horn on the anal segment. It reaches tw

inches in length and has a pale yellowish white color. In about 24 hours it builds a fine yellowish white cocoon of pure fine silk around itself and changes into the pupa inside the same and emerges as the adult moth in about 10 or 12 days. One cycle occupies about six to eight weeks according to seasons.

A few diseases often affect the worms and even cause serious mortality among them. The most important of these is what is known as "*Pebrine*"—a turning into pale brownish color of the worms during the later stages, shrinking and death; this is a very serious malady and is found affecting the silkworms all over the world. It is caused by a protozoan parasite *Nosema bombycis* and it is not only infectious but is transmitted from generation to generation through the eggs. The best recognized control against this disease is the microscopic selection of pebrine-free eggs. This method consists in examining the body fluid of the parent moth and discard or retain its eggs according as the fluid contains pebrine corpuscles or not. Other diseases like Flacherie, Grasserie, etc., are of minor importance and caused by viruses and insanitary methods of rearing and feeding worms.

Preparation of silk.—In a day or two after pupation, the cocoons are all dried in the hot sun or stifled with steam to kill the live pupa inside, for, in the case of mulberry cocoon, silk is reeled out into a long single thread from the cocoon, and as such, the moth coming out of the pupa is not allowed to pierce the cocoon. Only a few cocoons which are necessary for the seeds of the next generation are kept to allow the adults to emerge and lay eggs. Pierced cocoons cannot be reeled; they can only be spun like cotton. When all the cocoons are properly prepared, the silk is reeled out by the process of reeling which consists in soaking the cocoons in boiling water, drawing out the silk strands from the wet cocoons and reeling them in skeins. This is an art which requires some special skill on the part of reelers, though nowadays reeling machines are in vogue. The methods of rearing this silkworm in India are unsatisfactory in many ways; special attention has to be paid by rearers to—

(1) selection of disease-free seeds for rearing;

(2) feeding the worms with clean and nutritious leaves; and

(3) keeping the rearing trays and the sheds thoroughly clean and sanitary by proper disposal of dead worms and litter, and periodical disinfection of all rearing appliances. Carelessness in these important matters would bring in diseases and especially *Pebrine* which will wipe away worms in thousands.

The Eri and Tassar silkworms which belong to the same family (*Saturnidæ*) are not so important as the mulberry worm as regards the quality or bulk of silk produced. They are both large-sized moths and their caterpillars are stout and well built, reaching to four inches when full grown. Of the two, the Eri worm is a domesticated form while the Tassar is a semi-domesticated creature often

found wild breeding on various forest trees in different parts of India.

The Eri worm (*Attacus ricini, B.*, fig. 392), which lives on castor leaves thrives well in warm damp weather and cannot stand the hot season with high temperatures and dry winds. In South India, it can be reared successfully in the tracts all along the West Coast : in other places artificial adjustments must be made to rear it successfully.

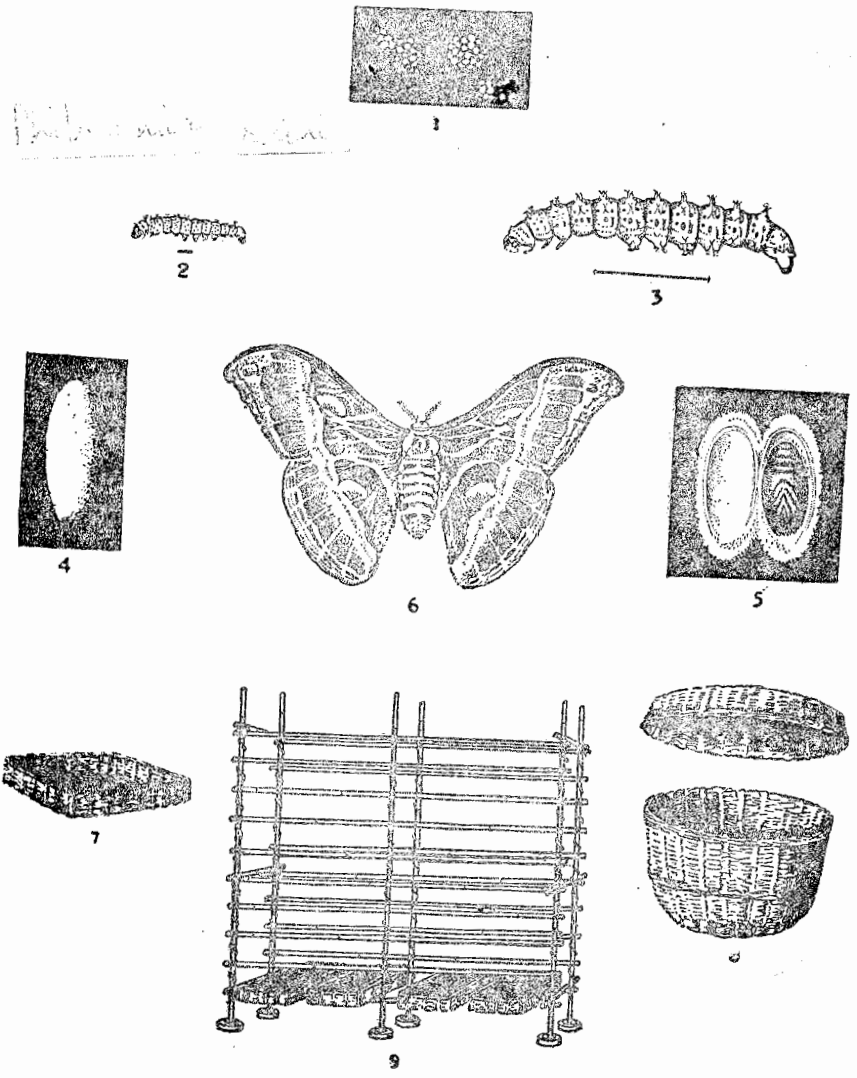


FIG. 392.—ERI SILK WORM STAGES AND REARING APPLIANCES.

(*Attacus ricini*, B.)

1 to 6 Eggs, caterpillars pupa and moth. 7 to 9 Appliances.

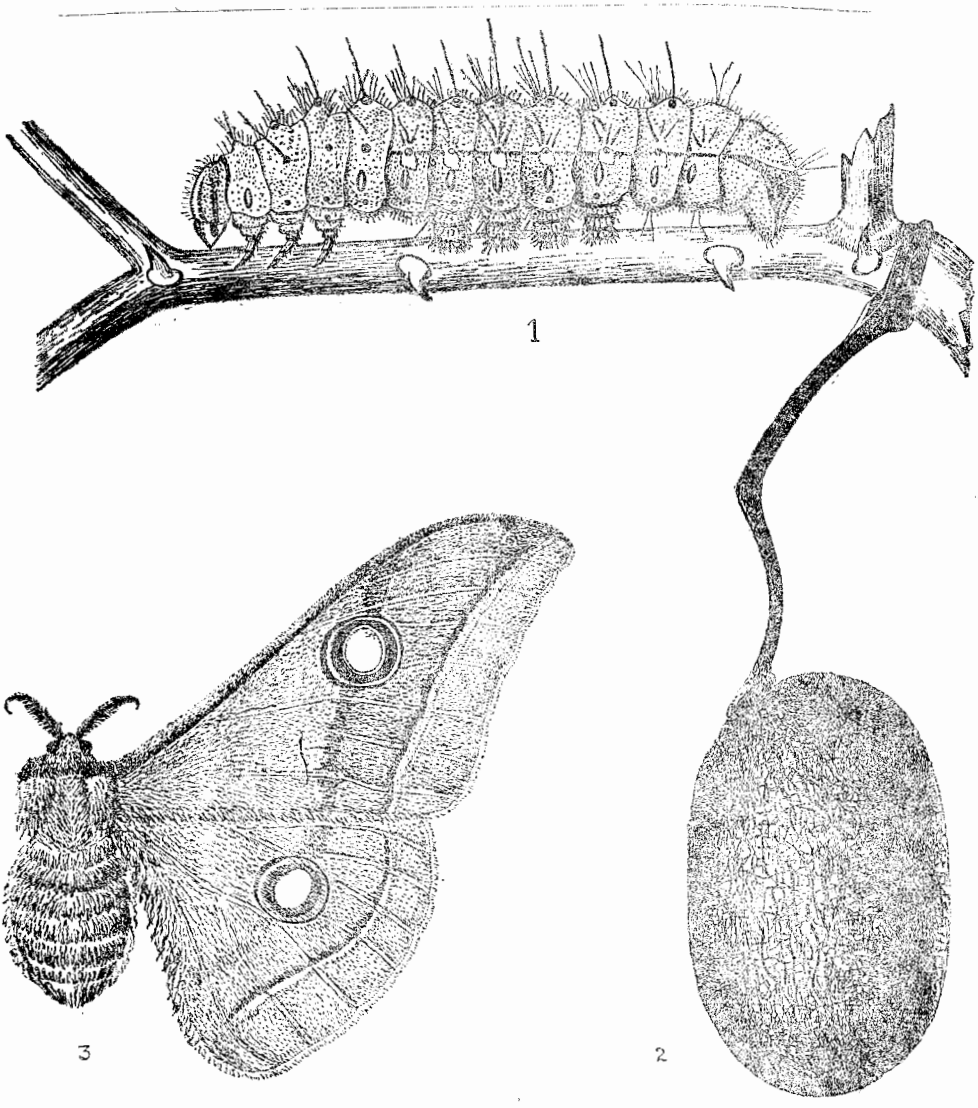


FIG. 393.—TASSAR SILKWORM STAGES.
(*Antherea paphia*, B.)

1 Worm. 2 Cocoon. 3 Moth.

[*From S.S.I.*]

The life history is more or less similar to the mulberry silk worm. The cocoon, however, is not so compact and is loose in texture compared to that of the mulberry worm and the silk too is not so fine and glossy. And unlike as in the case of mulberry worms, the cocoons are not stifled since the silk is not reelable and so the adults, which are stout dark moths with dark-brown white-spotted wings, are allowed to emerge from the cocoons. The silk in this case is merely carded and spun like cotton. The Tassar worm (*Antherea paphia* B., fig. 393),is more or less similar to the Eri, but is found

to feed on the foliage of different kinds of trees like *Dalbergia*, *Shorea*, *Terminalia*, etc. The cocoon is a large-sized hard shell-like structure as big as a hen's egg and attached to the food plant by means of a strong silken stalk; the moth is stout with yellowish or deep brown wings with an eye spot on each wing. Like the mulberry cocoon the silk in this case is reelable. Being a wild silkworm found in the forests, the Tassar silk we generally get is got from cocoons collected from the forests and sold by jungle tribes to silk manufactures.

Other silkworms allied to these creatures having no great economic importance are the Moon moth (*Actias selene*, fig. 52), the Atlas moth (*Attacus*)—one of the biggest of moths, the cashew caterpillar (*Cricula*, fig. 261) and the Ficus worm (*Ocinara varians*, W., fig. 394), the last resembling very much the mulberry worm and found on ficus leaves.

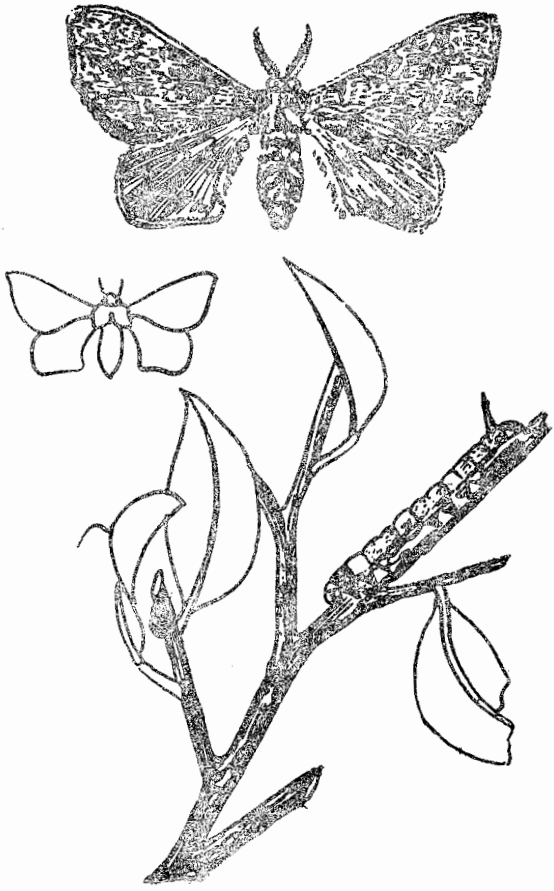


FIG. 394.—WILD SILKWORM AND MOTH.
(*Ocinara varians*, W.)

[*From S.S.I.*]

Lac.

Next to honey and silk the most important useful products we get from insects is the substance called *Lac* which when purified

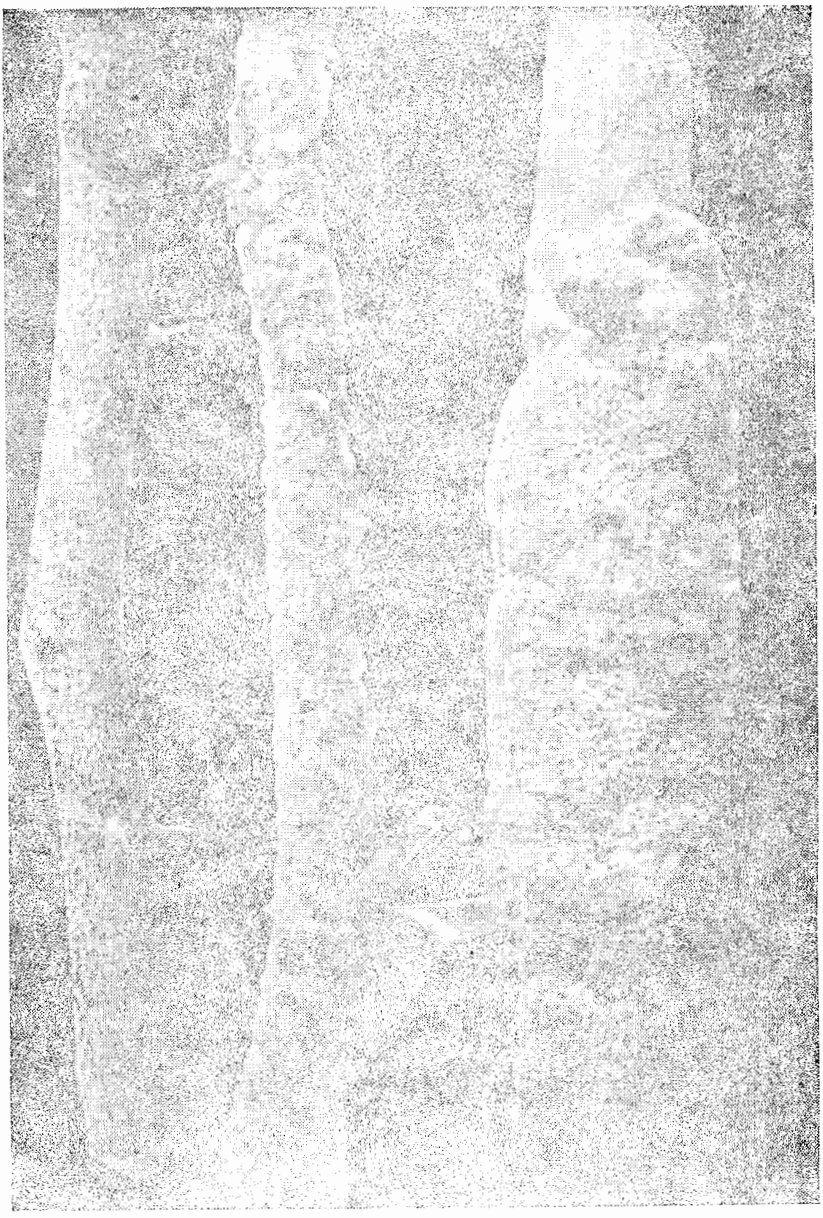


FIG. 395.—LAC ENCRUSTATION ON TWIGS.

[*From Pusa Bull*]

becomes the well known useful substance *Shellac*. Lac is the resinuous encrustation produced by a kind of scale insect called the lac insect (*Laccifer lacca*, K., fig. 395). Just like other scale insects (Coccidae) the creature secretes a scale to cover its body and this secretion takes the form of a brown resinuous substance which forms the 'shellac' of commerce. The general features and the life history of the lac insect are exactly similar to all other scale insects. The just hatched young are very small active little red creatures with three pairs of legs, two antennae and a sap sucking proboscis; they wander about the host plant for some hours after hatching from the egg and then fix themselves on the tender shoots by means of their sucking tubes and remain stationary. After a few moults the male insect which is either winged or wingless slowly crawls out while the female remains fixed to the tree and grows in size. The male fertilizes the stationary female after which the latter grows rapidly in size and gives rise to the next generation of young ones. The lac insect in India generally passes through two generations in the year. Usually hundreds of such female scales are found together on a tree branch and the scaly secretions of these forms a continuous encrustation of lac on the bark. This is scraped, thoroughly washed and used as lac or shellac. Until recently the lac dye got by washing the lac encrustation was extensively used for coloring silk, wool, etc., now that cheap aniline dyes are available, lac dye is not of any commercial value at present. The most important substance, therefore, is the pure resinuous lac got after removing the dye. Lac is used for various purposes—for filling hollow ornaments, cover dolls, etc., for lacquered wares, making gramaphone records, etc. The important trees on which the lac insect has been found to thrive are the Kusum (*Schleichera trijuga*), the Ber (*Zizyphus jujuba*), Palas (*Butea frondosa*), the Babul (*Acacia arabica*) and Sal (*Shorea robusta*); in Mysore lac is found on *Shorea tolura*. Occasionally the writer has collected lac on *Dalbergia*, Mango, Rain tree and *Ficus* trees also in South India. The quality of lac usually varies with the food plant of the insect and it is also probable that all these forms found on different trees belong to more than one species.

Lac is cultivated on a fairly large scale in the Central Provinces, Bengal, Bihar, Sind, Assam and Burma. In South India, though some work in this direction has been started in Mysore, hardly anything appreciable was done in this direction until recenlty in the Madras Presidency though it is possible to make such trials in some parts of the province since the writer has successfully bred lac both on *Butea* and on *Zizyphus* trees some years ago near Coimbatore. The Forest Department has recently started Lac cultivation trials in parts of the Presidency. It will be found that lac cultivation does not require as much attention or appliances as in the case of apiculture or silkworm rearing. Another insect product which was made use of till recently is what was known as the 'Cochineal' insect red colouring matter got by drying the cochineal bug; this has now been replaced by artificial aniline dyes.

Insects as drug and food.

Among other products from insects may be mentioned the blistering drug "*Cantharidine*" got from blister beetles (Cantharidæ) of different kinds. It may also be added that insects of different kinds like locusts, grubs of cockchafers and Stink bugs, some saturnid moth caterpillar and water beetles are used as food by men in different countries, but in South India, the only insect which is generally used as food by some classes of people is the winged white-ant or "*Easul*." Easul catching is a special pastime of some of the agricultural labourers during the rains and many devices are in vogue to collect the winged termites during the proper season. Koenig has described the method of termite catching for food in South India over a hundered and fifty years ago and the following account of the subject by Fletcher on the details of the method may be interesting (fig. 396).

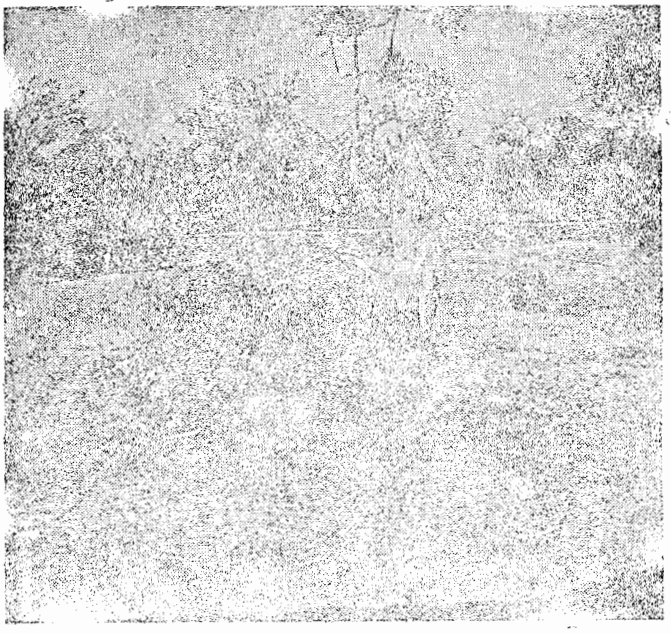


Fig. 396.—Termite catching in South India.
(1) Termitarium complete.

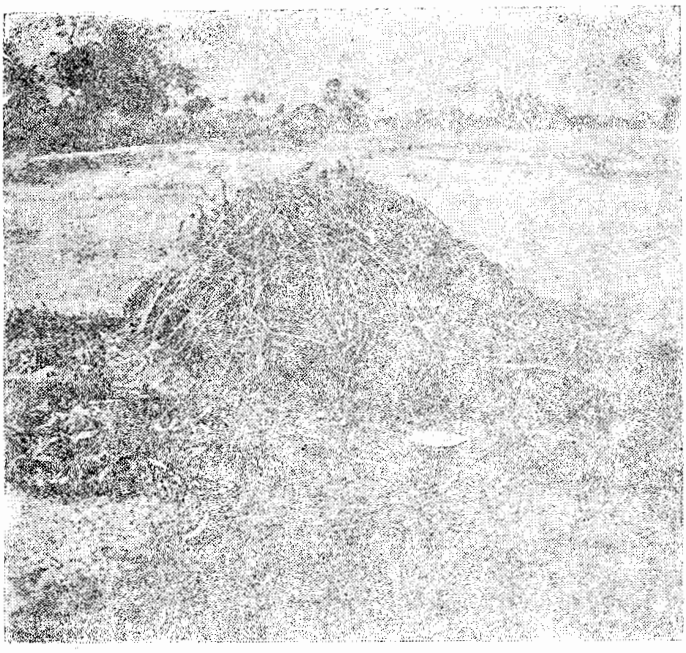


FIG. 396 (2).—TERMITARIUM EARLY STAGES.

"At Coimbatore the emergence of the winged Termites is said to occur as a rule after the first rainfall in the Tamil month of *Audi*, corresponding to July. At this time of the year the professional Termite catcher (known as a *Valayan* in these parts) selects a suitable mound, slices off the top level with the ground and pours water over it. A framework in the shape of a small domed hut is then built over the mound composed of twigs and small branches of the Babul (*Acacia arabica*) or some other tree, and this framework is then covered thickly with the leafy twigs. A small opening of a size sufficient to admit one's hand is left in the framework though this also is utilmately closed up with leaves. Close to this opening and about the centre of the mound is excavated a pit about a foot deep and 12 inches in diameter and the mouth of this pit is narrowed by placing leaves of (*Calotropis gigantea*) (*Tamil-yerukam*) around it. The inside of the pit is smoothly plastered with mud and is then half filled with water. Or sometimes an earthernware pot is buried in the pit and this is half filled with water. Everything being now in readiness, the *Valayan* takes a small quantity of a powder made of equal proportions of the roots of *Tephrosia spinosa* (*Tamil-Mulkolingi*) and the seeds of *Erythrina indica* (*Tamil-Mulmurungai*), baked and powdered together, and blows this powder into one of the main galleries exposed by slicing off the top of the nest. This powder is said to cause the termites some inconvenience and to hasten their emergence. Having blown the powder in, the *Valayan* lights a small lamp and places it by the side of the pit, and then closes up the hut with leaves. The winged termites fly out and fall into the water contained in the cavity, in which they are collected. A reasonably good catch is said to yield as much as two Madras measures (of about 3 lb. weight each) from a single termiterium. After collection the termites are dried in the sun, when their wings become detached; in this state they are sold in the local bazaars at a price of about four annas for a Madras measure, but they are only available in the bazaars at this particular season of the year. They are eaten raw mixed with parched ('popped') paddy. Only the lower castes eat this food." (Page 328, Proc. IV, Ent. Meet. Pusa, 1921.)

HELPFUL INSECTS.

This category of insects includes all forms which by their life activities help man in controlling his plant and animal pests. These are insect friends of the farmer as different from the various pests which are his foes. The most important of these friendly insects are the many insect feeding or *entomophagous* forms including *Predators, Stinging predators and Parasites* (fig. 397). Reference

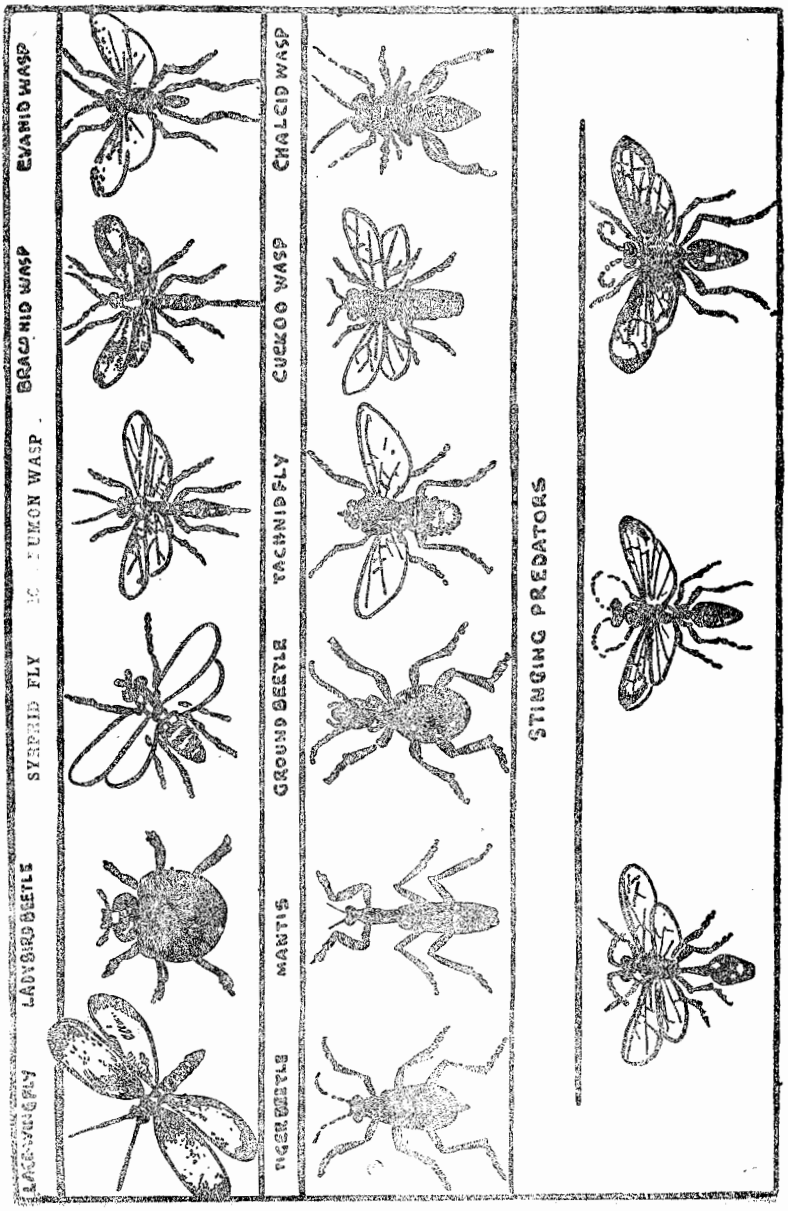


FIG. 397.—HELPFUL INSECTS.

has been already made to the work of these natural enemies at some length in Chapter V, when dealing with the inter-relations of insects and in Chapter IX when referring to the biological methods of insect pest control.

Predators.—Some of the well-known among predatory insects are the Mantises, Dragon flies, Lace wing flies (*Chrysopids*), Ant lions. Ground beetles (*Carabids*), Tiger beetles (*Cicindelidae*), Lady-bird beetles (*Coccinellidae*), Hover flies (*Syrphidæ*), Robber flies (*Asilidæ*), Assassin bugs (*Reduviidæ*) and some predatory caterpillars (such as *Eublemma, Phycita, Spalgius*). The lady-bird beetles play a very important part as predators of economic importance. The commonest of these found in South-India are spp. of *Chilomenes, Scymnus, Chilocorus, Coccinella, Clanis, Brumus* and *Pullus*. Of the stinging predators which hunt their prey and store them as food for their young ones are the various solitary, social and digging wasps (chiefly of the families Sphegidæ, Pompilidæ, Scoliidæ and Eumenidæ).

Parasites.—Coming to entomophagous parasites, we have hundreds of these creatures doing remarkably useful work in nature. The commonest of these are the main groups of parasitic wasps (Hymenoptera) and the family of parasitic flies (Tachinidæ). The well-known groups among the hymenopterous parasites are the Ichneumonid, the Braconid and the Chalcid wasps. Of the Tachinid flies, we have species of the genera *Sturmia, Cyphocera, Tachinia, Winthemia, Exorista* parasitising pests like the paddy army worm, tea slug, fruit moth larva, etc. Some of our important pests like the paddy stem borer, tobacco caterpillar, gram caterpillar, red hairy caterpillar and the paddy swarming caterpillar are all subject to the attacks of one or more of such wasp or fly parasites, and these latter very often contribute their substantial share in checking the otherwise rapid multiplication of many notorious pests. The author has published some papers on these useful insects and information may be found in those publications. The possible methods of utilizing these useful forms for the benefit of the farmer have been already referred to in the chapter on control measures.

Weed killers.—In addition to the more important of the helpful insects noted above we have among insects such forms as weed killers, scavengers, and flower pollinators. The most important of these in South India is the prickly-pear cochineal insect (*Dactylopius tomentosus*, L., fig. 398) which has helped us in practically exterminating the prickly-pear nuisance all over South India. As is well-known, this insect which is a native of Mexico, was introduced via Ceylon into South India only about five or six years ago and it is clear to every one that it has done remarkable work within this short period. The lantana which is a very troublesome weed in the hill plantations is also checked to a great extent by the Lantana bug (*Orthezia insignis*, D. fig. 399). But this bug attacks useful

plants also and as such, is not an exclusively friendly insects like the Cochineal. The lantana seed fly (*Agromyza lantanae*, fig. 400), which is said to be an efficient natural enemy of lantana in Hawai and other countries and which was till now believed to be absent in India has been recently discovered by Subramanian, the Mysore Entomologist to exist in different parts of India. It does not, however, appear to be an efficient check on lantana in this country. Very little investigation has been made in this line of finding out

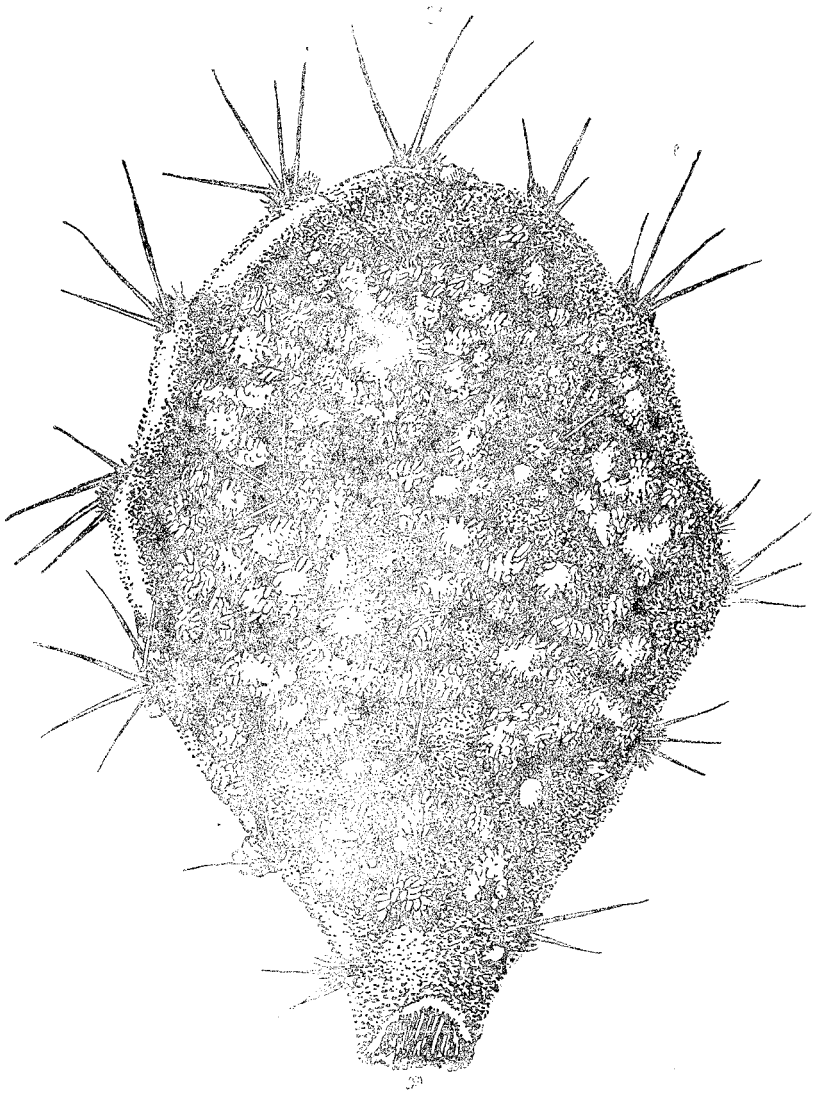


FIG. 398.—PRICKLY-PEAR COCHINEAL.
(*Dactylopius tomentosus*, L.)
[*From* ***Trop. Agr. Ceylon***]

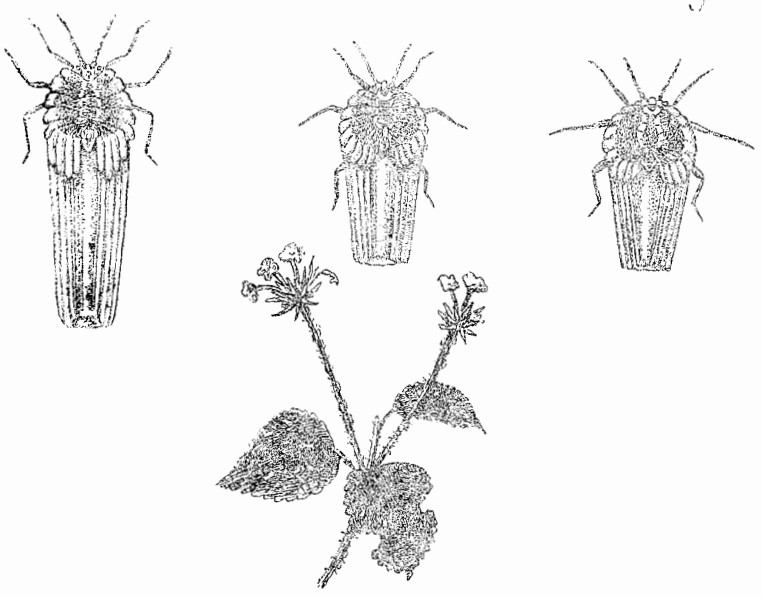


FIG. 399.—THE LANTANA BUG.
(*Orthezia insignis*, D.)

the insect enemies of various plant pests and it will be a very useful line of work if we are able to find out efficient local or exotic insects which would help us to control such plant pests like water hyacinth, the Khaki weed, *Mimosa*, *Tribulus*, hill *Eupatorium* and other noxious weeds found all over South India.

Scavengers.—Finally, we have numerous insects which play the role of scavengers feeding on dead animals and vegetable matter of all kinds and helping to keep the surface of the earth clean and sanitary. Well-known examples of such forms among insects are the dung roller beetles (*Copriidae*, fig. 401), beetle borers of dead wood (*Bostrychidae*), White ants (*Termitidæ*), carrion beetles (*Cleridæ*), beetle borers of bark, stem, etc. (*Passalidæ*, *Scolytidæ*, *Cerambycidae*, etc.), flesh flies (*Sarcophagidæ*), Hover flies (*Syrphidae*), the screw worm flies of the family *Muscidae* and a host of others.

FIG. 400.—LANTANA SEED FLY.

A. Lantana fruit clusters.
B. Attacked berries.
C. Fly stages.
D. Pupa in pulp.

[After T.V.S., Mysore]

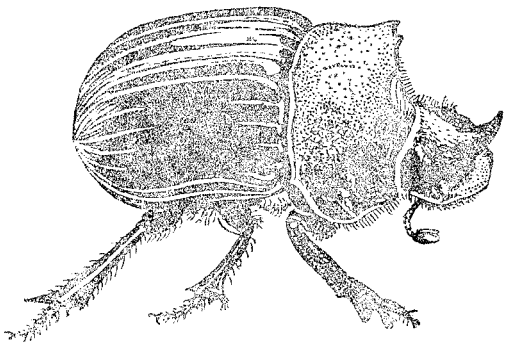


FIG. 401.—DUNG ROLLER BEETLE.
(*Heliocopris bucephalus*, F.)

[*After Howlett*]

Flower pollinators.—Certain plants especially some fruit trees depend upon insect of sorts for their proper growth and for reproduction; among such forms are bees of different kinds, some flies, butterflies and moths. The fig polinating wasp (*Blastophaga* fig. 51) is a well known example.

APPENDIX A.

SOUTH INDIAN CROP PESTS ARRANGED ACCORDING TO THE NATURAL ORDERS WITH THEIR IMPORTANT FOOD PLANTS.*

ORDER—ORTHOPTERA.

	Chief host plants.
Family—Acrididæ—	
Hieroglyphus banian, Fb.	Paddy.
Hieroglyphus orizivorus, U.	Do.
Colemania sphenarioides, B.	Cholam, tenai, cumbu.
Atractomorpha crenulata, Fb, ...	Tobacco.
Oxya velox, F.	Paddy.
Chrotogonus saussurei, B.	Cholam, cotton.
Acrotylus humbertiana, S.	Paddy nurseries.
Heteropternis respondens, W.	
Locusta danica, L.	
Pyrgomorpha conica, O.	
Aelopus affinis, B.	
Orthacris simulans, B.	Ragi.
Cyrtacanthacris ranacea, S.	Cotton.
Orthacris elegans, B.	Maize.
Oedaleus sp.	Ragi.
Catantops annexus, C.	Cotton.
Aelopus tamulus, F.	Do.
Poecilocerus pictus, F.	Calotropis.
Aularches miliaris, L.	Coffee.
Chrotogonus robertsoni, B.	Tobacco.
Gesonia punctifrons, S.	Colocasia.
Family—Gryllidæ—	
Brachytrypes portentosus, L.	Casuarina seedlings.

ORDER—ISOPTERA.

Family—Termitidæ—	
Microtermes obesi, Hol.	Wheat.
Odontotermes obesus W.	Sugarcane.
Eutermes heemi, W.	Do.

ORDER—HYMENOPTERA.

Family—Tenthredinidæ—	
Athalia proxima, K.	Cruciferous plants.
Family—Chalcididæ—	
Bruchophagus mellipes, G.	Sesbania *spp.*
Eurytoma chrysothrix, W.	Bamboo shoots.
Family—Apidæ—	
Megachile anthracina, S.	Rose and other garden shrubs.

* With slight changes from Author's Bulletin Madras Agricultural Department No. 27–1932. Some insects in this list are not referred to in the text.

ORDER—HYMENOPTERA—*cont.*

	Chief host plants.
Family—*Formicidæ*—	
Dorylus orientalis, W.	Sugarcane.
Solenopsis geminata, F.	Brinjal.
Oecophylla smaragdina, F.	Mango and other trees.
Camponotus compressus, F.	On various plants, chiefly a plant lice distributor.

ORDER—COLEOPTERA.

Family—*Melolonthidæ*—	
Serica nilgiriensis, S.	Cinchona.
Serica pruinosa, S.	Coffee.
Holotrichia conferta, S.	Do.
Holotrichia repetita, S.	Cinchona.
Rhizotrogus rufus, A.	Do.
Family—*Rutelidæ*—	
Popillia chlorion, N.	Cinchona.
Adoretus versutus, H.	Grape-vine.
Adoretus lasiopygus, B.	Do.
Anomala varians, O.	Garden plants.
Family—*Cetoniadæ*—	
Anatona stillata, N.	Cholam.
Oxycetonia versicolor, F.	Do.
Protaetia aurichalcea, F.	Do.
Chiloloba acuta, W.	Cholam and cumbu.
Family—*Dynastidæ*—	
Oryctes rhinoceros, L.	Palms.
Xylotrupes gideon, L.	Coconut.
Phyllognathus dionysius, F.	Paddy.
Family—*Erotylidæ*—	
Anadastus parvulus, W.	Tenai.
Family—*Coccinellidæ*—	
Epilachna 12 punctata, M.	Brinjal, Cucurbitaceæ, Potato.
Epilachna 28 punctata, F.	Do.
Family—*Tenebrionidæ*—	
Gonocephalum hoffmanseggi, S. and Opatrum *sp.*	Grape-vine, Potato.
Gonocephalum depressum F.	Do.
Opatroides frater, F.	Tobacco.
Seleron latipes, G.	Do.
Family—*Meloidæ*—	
Zonabris pustulata, Th.	Flowers of various plants.
Mylabris balteata, B.	Groundnut, grasses, etc.
Psalydolytta rouxi, C.	Earheads of paddy and other cereals.
Lytta ruficollis, O.	Do.

ORDER—COLEOPTERA—*cont.*

	Chief host plants.
Family—*Meloidæ*—cont.	
Lytta (Cylindrothorax) tenuicollis, P. ..	Earheads of paddy and other cereals.
Epicauta *sp.*	Paddy ears.
Cantharis setacea	Cowpea.
Family—*Buprestidæ*—	
Sphenoptera gossypii, K.	Cotton.
Sphenoptera perotetti, G.	Groundnut.
Psiolptera fastuosa, F.	Teak.
Belinota prasina, Th.	Mango.
Trachys bicolor, K.	Butea.
Trachys ipomœa, Th.	Sweet potato.
Family—*Elateridæ*—	
Drasterius *sp.*	Potato.
Family—*Cerambycidæ*—	
Batocera rufomaculata, Ga.	Mango, jak, rubber, fig, etc.
Chloridolum alcamene, T.	Citrus varieties.
Chelidonium cinctum, G.	Do.
Xylotrechus quadripes, Ch.	Coffee.
Apomecyna pertigera, Th.	Cucurbitaceæ.
A. perotetti, F.	Do.
Sthenias grisator, F.	Garden plants, mulberry, grape, etc.
Stromatium barbatum, F.	Bamboo.
Coelosterna scabrator, F.	Casuarina.
Coelosterna spinator, F.	Do.
Heresium simplex, G.	Do.
Olenecamptus bilobus, F.	Ficus *spp.*
Monohammus nivosus, W.	Calotropis.
Oberea brevis, S.	Cowpea, Soyabean.
Coptops asditcator, F.	Moringa.
Placæderus ferrugineus, L.	Cashew.
Prionoma atratum, G.	Do.
Family—*Chrysomelidæ*—	
Podagria bowringi, B.	Hibiscus.
Sagra nigrita, Ol.	Dolichos lab-lab.
Scelodonta strigicollis, Mots	Grape-vine.
Oides affinis, Ja.	Paddy.
Aulacophora stevensi, B.	Cucurbitaceæ, Lucerne.
Aulacophora foveicollis, F.	
Aulacophora atripennis, F.	
Galerucida bicolor, H.	Elephant-foot yam.
Podagria madurensis, J.	Gogu.
Monolepta signata, O.	Cotton, Colocasia.
Chalænosoma metallicum, J.	Potato.
Clitea indica, J.	Bael.
Chætocnema *sp.*	Ragi.
Lema downsei, B.	Do.
Chætocnema pusænsis, M.	Millets.

ORDER—COLEOPTERA—*cont.*

	Chief host plants.
Family—*Chrysomelidæ*—cont.	
Pagria castatipennis, J.	Pepper.
Neculla pollinaria, B.	Do.
Longitarsus nigripennis, M.	Do.
Longitarsus belgaumensis, F.	Sunnhemp.
Hermacophaga ruficollis, L.	Castor.
Phyllotreta downsei, B.	Cruciferae.
Haltica cyanea, J.	Paddy, Ammania.
Aspidomorpha miliaris, F.	Sweet potato.
Metriona circumdata, H.	Do.
Chiridia sexnotata, B.	Do.
Leptispa pygmœa, B.	Paddy.
Oncocephala tuberculata, Ol.	Sweet potato.
Platypria andrewsi, W.	Zizyphus jujuba.
Platypria echidna, G.	Erythrina.
Platypria hystrix, F.	Sesbania, Erythrina, etc,
Dicladispa (Hispa) armigera, O.	Paddy.
Physodonta cuspidata, W.	Sugarcane.
Corynodes *sp.*	Coffee.
Cassida exilis, B.	Amaranthus.
Family—*Bruchidæ*—	
Bruchus theobromæ, L.	Redgram.
Family—*Anthribidæ*—	
Araecerus fasciculatus, de. G.	Areca, coffee.
Family—*Curculionidæ*—	
Blosyrus inæqualis, B.	Cluster beans.
Sympiezomias frater, M.	Coffee.
Sympiezomias decipiens, M.	Orange, cinchona.
Dereodus mastos, H.	Gogu.
Episomus lacerta, F.	Pulses.
Myllocerus discolor, F.	Cholam.
Myllocerus transmarinus, H.	Tenai.
Myllocerus dentifer, F.	Paddy.
Myllocerus viridanus	Groundnut, bhendsi.
Myllocerus subfasciatus, G.	Brinjal.
Atactogaster finitimus, F.	Cotton.
Hypolixus truncatulus, B.	Amaranthus.
Paramecops farinosus, W.	Calotropis.
Apoderus tranquebaricus, F.	Mango, Terminalia.
Cylas formicarius, F.	Sweet potato.
Eugnamptus (*Deporaus*) marginatus, P.	Mango.
Apion amplum, F.	Greengram, cashew.
Alcidodes pictus, B.	Lab-lab.
Alcidodes bubo, Fb.	Agathi, indigo.
Alcidodes collaris, P.	Pulses.
Alcidodes affaber, F.	Gogu, Bhendi.
Alcidodes fabricii, F.	Pulses and agathi.

Order—COLEOPTERA—*cont.*

	Chief host plants.
Family—*Curculionidæ*—cont.	
Pachytychius mungonis, M.	Greengram.
Ceuthorhynchus asperulus, F.	Redgram.
Rhynchænus mangiferae, M.	Mango.
Prodioctes haematicus, Ch.	Cardomom.
Pachyonyx quadridens, Ch.	Butea.
Cryptorhynchus mangiferae, F.	Mango.
Pempherulus affinis, F.	Cotton.
Baris *sp.*	Snake-gourd.
Acythopius citrulli, M.	Melon.
Rhynchophorus ferrugineus, F.	Palms.
Amorphoidea arcuata, M.	Cotton.
Cosmopolites sordidus, G.	Plantain.
Calandra stigmaticollis, G.	Coconut.
Ochyromera artocarpi, M.	Jak.
Athesapeuta oryzæ, M.	Paddy.
Echinocnemus oryzæ, M.	Do.
Amblyrrhinus poricollis, B.	Country almond.
Conarthus jansoni, Woll	Bamboo.
Colobodes dolichotis, M.	Dolichos-Lab-lab.
Balaninus-C-album	Jambu.
Family—*Scolytidæ*—	
Xyleborus compactus, E.	Coffee.
Xyleborus fornicatus, E.	Castor, coffee and tea.
Xyleborus morstatti, E.	Coffee.
Hypothenemus plumeriae, N.	Morinda.
Xyleborus biporus, S.	Rubber.
Xyleborus semigranosus, B.	Tea.
Xyleborus parvulus, E.	Coconut.

Order—LEPIDOPTERA.

Family—*Arctiadæ*—	
Amsacta albistriga, W.	Groundnut, cumbu, cholam, etc.
Pericallia ricini, F.	Castor, plantain, etc.
Utetheisa lotrix, L.	Sunnhemp.
Estigmene lactinea, C.	Cumbu, ragi, etc.
Diacrisia obliqua, W.	Sweet potato.
Family—*Noctuidæ*—	
Spodoptera mauritia, B.	Paddy, grasses.
Heliotnis armigera, F.	Pulses, ganja, tobacco.
Heliothis peltigera, S.	Safflower.
Heliothis assulta, C.	Tobacco.
Agrotis C-nigrum, L.	Cruciferæ.
Euxoa segetum, S.	Potatoes and other garden crops on the hills.
Rabila frontalis, W.	Cotton.
Adisura atkinsoni, M.	Lab-lab and other legumes.

ORDER—LEPIDOPTERA—*cont.*

	Chief host plants.
Family—*Noctuidæ*—cont.	
Sesamia inferens, W.	Ragi, wheat, cane, etc.
Cirphis albistigma, M.	Paddy grasses.
Cirphis unipuncta, H.	Cholam.
Cirphis loreyi, D.	Cholam, paddy.
Cirphis micacea, H.	Paddy.
Borolia venalba, M.	Do.
Prodenia litura, F.	Tobacco, plantain, castor, etc.
Laphygma exigua, Hb.	Maize, lucerne, onions, chillies, etc.
Polytela gloriosæ, F.	Garden lilies.
Perigoea capensis, G.	Safflower.
Amyna octo, G.	Sunnhemp, pulses, ganja.
Eublemma silicula, S.	Cholam.
Eublemma olivacea, W.	Brinjal.
Bombotelia jocosatrix, G.	Mango.
Orthaga exvinacea, M.	Do.
Chlumetia transversa, W.	Do.
Cryptothrips occulta, S.	Brinjal.
Selepa celtis, M.	Ficus *spp.*
Earias fabia, S.	Cotton and other malvaceae.
Earias insulana, B.	Do.
Tarache nitidula, F.	Cotton and calotropis.
Trache notabilis, W.	Do.
Carea subtilis, W.	Eugenia.
Acontia graellsi, F.	Cotton and Hibiscus *spp.*
Anomis flava, H. G.	Do.
Catephia inquieta, W.	Sweet potato.
Achoea janata, L.	Castor, pomegranate.
Grammodes stolida, F.	Linseed.
Anticarsia irrorata, B.	Pulses.
Pelamia frugalis, F.	Paddy and grasses.
Pericyma glaucinans, G.	Sesbania.
Phytometra chalcytes, F.	Groundnut.
Plusia signata, F.	Do.
Phytometra peponis, F.	Snake-gourd.
Plusia orichalcea, F.	Indigo.
Othereis fullonica, L. and **O.** materna, L.	Citrus plants.
Simplicia robustalis, G.	Ragi and thatching stacks.
Hybloea puera, Cr.	Teak, Millingtonia and Bignonia.
Celama internella, W.	Cholam ears.
Family—*Syntomidæ*—	
Euchromia polymena	Sweet potato, L.
Family—*Lymantridæ*—	
Dasychira horsefieldi, S.	Tea.
Euproctis fraterna, M.	Castor, cotton, redgram, pomegranate and rose.

ORDER—LEPIDOPTERA—*cont.*

	Chief host plants
Family—*Lymantridæ*—cont.	
Euproctis lunata, W.	Babul trees.
Porthesia scintillans, W.	Gogu, mango, etc.
Psalis securis, H.	Paddy and grasses.
Thiacidas postica, W.	Zizyphus.
Notolopus postica, W.	Castor.
Perina nuda, Fb.	Ficus.
Dasychira (Olene) mendosa, H.	Castor.
Family—*Hypsidæ*—	
Hypsa ficus, F.	Ficus species.
Argina syringa, G.	Sunnhemp.
Argina cribraria, C.	Do.
Family—*Sphingidæ*—	
Acherontia styx, W.	Lal-lab, gingelly and brinjal.
Deilephila nerii, L.	Garden oleander.
Hippotion oldenlandiae, F.	Colocasia.
Hippotion celerio, L.	Grape-vine.
Herse convolvuli, L.	Sweet potato and green-gram.
Macroglossa vialis, B.	Morinda.
Rhopalopsyche bifasciata, B.	Do.
Rhyncholaba acteus, C.	Colocasia.
Family—*Eupterotidæ*—	
Eupterote mollifera, W.	Moringa.
Nisaga simplex, W.	Paddy, grasses.
Eupterote canaraica	Cardomom.
Family—*Bombycidæ*—	
Ocinara varians, W.	Ficus *spp.*
Family—*Saturnidæ*—	
Cricula trifenestrata, H.	Mango, cashew and pepper.
Actias selene, Hb.	Moringa and odina.
Family—*Notodontidæ*—	
Stauropus alternus, W.	Red-gram and tamarind.
Turnaca acuta, W.	Coconut.
Family—*Cochlididæ*—	
Latoia lepida, Cr.	Castor, palms and mango.
Altha nivea, W.	Castor.
Contheyla rotunda, H.	Coconut.
Macroplectra nararia, M.	Coconut and Pithecolobium dulce.
Belippa laleana, M.	Coffee.
Thosea cervina, M.	Tea.
Family—*Geometridæ*—	
Buzura (Biston) suppressaria, G. ..	Tea.
Semiothisa pervolgata, W.	Daincha.
Hyposidra successaria, W.	Do.

ORDER—LEPIDOPTERA—*cont.*

	Chief host plants.
Family—*Lasiocampidæ*—	
Metanastria hyrtaca, Cr.	**Acacia and other trees.**
Taragama siva, L.	Acacia.
Family—*Pyralidæ*—	
Ancylolomia chrysographella, K.	Paddy.
Schoenobius incertulas, W.	Do.
Scirpophaga monostigma, W.	Sugarcane.
Scirpophaga nivella, F.	Do.
Chilotroea infuscatellus, H.	Do.
Proceros indicus, W.	Do.
Chilo zonellus, S.	Cholam and ragi.
Stenachroia elongella, H.	Cholam.
Saluria inficita, W.	Ragi.
Euzophera perticella, R.	Brinjal and chillies.
Euzophera plumbeifasciella, H.	Wood-apple.
Phycita infusella, M.	Cotton.
Phycita clientella, Z.	Brinjal.
Psara bipunctalis, F.	Do.
Psara phacopteralis, G.	Grasses.
Heterographis bengalella, Rag	Custard apple.
Nymphula depunctalis, G.	Paddy.
Etiella zinckenella, T.	Sunnhemp, pulses.
Hymenia fascialis, C.	Amaranthus and grasses.
Marasmia trapezalis, G.	Cholam, maize, etc.
Cnaphalocrocis medinalis, G.	Paddy.
Sylepta derogata, Fb.	Cotton and other malvaceous plants.
Dichocrocis punctiferalis, G.	Castor, turmeric, arrow root and ginger.
Lamprosema indicata, F.	Garden chrysanthemums and pulses.
Lamoria *sp.*	Boring into pungam pods.
Sylepta lunalis, G.	Grape-vine.
Crocidolomia binotalis, Z.	Cruciferous plants.
Leucinodes orbonalis, G.	Brinjal.
Margaronia stolalis, G.	Ficus *spp.*
Margaronia indica, S.	Cucurbitaceous plants.
Margaronia caesalis, W.	Jak.
Maruca testulalis, G.	Pulses.
Omphisa anastomosalis, D.	Sweet potato.
Hellula undalis, Fb.	Cabbage.
Glyphodes glauculalis, G.	Tabernæmontana.
Glyphodes phyloalis, W.	Fig.
Glyphodes unionalis, H.	Jasmine.
Antigastra catalaunalis, D.	Gingelly.
Terastia meticulosalis, C.	Erythrina.
Agathodes ostentosus, H.	Do.
Noorda blitealis, W.	Moringa.
Noorda moringæ, M.	Do.

ORDER—LEPIDOPTERA—*cont.*

	Chief host plants.
Family—*Pyralidæ*—cont.	
Protrigonia zizanialis, S.	Moringa.
Pyrausta (Hapalia) machoeralis, W. ..	Teak.
Pycnarmon cribrata, F.	Coleus (Koorkan).
Phostria piasusalis, W.	Do. do.
Myelois pectinicornilla, H.	Castor.
Nephopteryx ugraphella, R.	Sapota.
Family—*Psychidæ*—	
Clania crameri, W.	Acacia.
Kophene cuprea, M.	Banana.
Chaliodes vitrea, H.	Tamarind.
Pteroma plagiophleps, H.	Do.
Family—*Zygaenidæ*—	
Heterusia virescens, B.	Tea.
Family—*Zeuzeridæ*—	
Azygophleps scalaris, F.	Agathi and daincha.
Zeuzera coffeae, N.	Coffee.
Family—*Metarbilidae*—	
Indarbela tetraonis, M.	Citrus, mango and other trees.
Indarbela theivora, H.	Tea.
Family—*Pterophoridæ*—	
Oidaematophorus lienigianus, Z. ..	Brinjal.
Exelastes atomosa, W.	Red-gram.
Sphenarches caffer, Z.	Bottle-gourd.
Oxyptilus regulus, M.	Grape.
Family—*Tortricidæ*—	
Homona coffearia, N.	Coffee.
Family—*Carposinidæ*—	
Meridarches scyrodes, M.	Zizyphus.
Batrachedra arenosella, F.	Coconut.
Family—*Eucosmidæ*—	
Eucosma critica, M.	Redgram.
Laspeyresia leucostoma, M.	Tea.
Laspeyresia tricentra, M.	Sunnhemp.
Laspeyresia torodelta, M.	Lab-lab.
Argyroploce illepida, M.	Woodapple.
A. Aprobola	Mango.
Family—*Gelechiadæ*—	
Stomopteryx subsecivella, M.	Groundnut.
Platyedra gossypiella, S.	Cotton.
Gnorimoschema operculella, Z.	Potato.
Pthorimoea blapsigona, M.	Brinjal.
Pthorimoea heliopa, L.	Tobacco.
Lecithocera (Brachmia) effera, M. ..	Sweet potato.
Dichomeres ianthes, M.	Indigo.
Dactylethra candida, S.	Wild indigo.
Cocconympha [illegible]darcha, M.	Coconut.

ORDER—LEPIDOPTERA—*cont.*

	Chief host plants.
Family—*Oecophoridæ*—	
Psorosticha (Tonica) zizyphi, St. ..	Citrus plants.
Family—*Thyrididæ*—	
Striglina scitaria, M.	Daincha.
Family—*Xyloryctidæ*—	
Nephantis serinopa, M.	Coconut and other palms
Family—*Glyphipterygidæ*—	
Phycodes radiata, O.	Ficus *spp.*
Family—*Cosmopterygidæ*—	
Pyroderces falcatella, St.	Custard apple.
Cosmopteryx mimetis, M.	Lab-lab.
Family—*Ptutellidæ*—	
Plutella maculipennis, C.	Cruciferous plants
Family—*Gracillariadæ*—	
Acrocercops syngramma, Meyr.	Mango.
A. coerulea, M.	Lab-lab.
Gracillaria soyella, V. D.	Redgram.
Gracillaria theivora, W.	Tea.
Family—*Lyonetiadæ*—	
Phyllocnistis citrella, St.	Citrus plants.
Phyllocnistis toparcha, M.	Grape-vine.
Phyllocnistis chrysopthalma	Cinnomon.
Family—*Hepialidæ*—	
Phassus malabaricus, M.	Erythrina.
Family—*Nymphalidæ*—	
Euploea core, C.	Oleander.
Melanitis ismene, C.	Paddy.
Euthalia garuda, M.	Mango.
Danais chrysippus, L.	Calotropis.
Junonia orithyia, L.	Sweet potato.
Ergolis merione, Cr.	Castor.
Rapala melampus, C.	Mango.
Family—*Papilionidæ*—	
Papilio demoleus, L.	Citrus and Murrayia.
Papilio polytes, L.	Do.
Papilio agamemnon, L.	Champaka.
Family—*Pieridæ*—	
Catopsilia pyranthe, L.	Sesbania.
Terias hecabe, L.	Do.

ORDER—LEPIDOPTERA—*cont.*

	Chief host plants.
Family—*Lycaenidæ*—	
Chilades laius, C.	Citrus plants.
Polyommatus (Lampydes) boeticus, L...	Pulses.
Euchrysops cnejus, Fb.	Do.
Virachola isocrates, F.	Pomegranate.
Tarucus theophrastus, F.	Zizyphus.
Curetis thetis, F.	Pongamia tree.
Family—*Hesperiadæ*—	
Parata alexis, F.	Pongamia.
Gangara thyrsis, M.	Coconut.
Udaspes folus, Cr.	Turmeric.
Telicota augias, L.	Sugarcane.
Pelopidas (Parnara) mathias, F. ..	Paddy.
Parnara colaca, M.	Do.
Suastus gremius, F.	Coconut.

ORDER—DIPTERA.

Family—*Cecidomyidae*—	
Pachydiplosis oryzae, M.	Paddy.
Asphondylia sesami, F.	Gingelly.
Asphondylia pongamiae, F.	Pongamia.
Dasyneura gossypii, F.	Cotton.
Dasyneura mangiferae, F.	Mango.
Contarinia andropogonis, F.	Cholam.
Lasioptera falcata, F.	Bitter-gourd.
Rhabdophaga mangiferae, M.	Mango.
Stitodiplosis moringai, M.	Mango.
Family—*Agromyzidæ*—	
Agromyza obtusa, M.	Redgram.
Agromyza phaseoli, C.	Cowpea.
Family—*Micropezidæ*—	
Calobata *sp.*	Turmeric and ginger.
Family—*Trypaenidæ*—	
Leptoxyda longistylus, W.	Calotropis.
Dacus **brevistylus, B.**	Melons.
Chaetodacus ferrugineus, dorsalis, H. ..	Mango, citrus.
Chaetodacus incisus, W.	Guava.
Chaetodacus zonatus, S	Custard apple.
Chaetodacus correctus, B.	Eugenia, mango.
Chaetodacus cucurbita, C.	Cucurbitaceae.
Chaetodacus caudatus, F.	Snake-gourd.
Chaetodacus dorsalis, C.	Mango.
Carpomyia vesuviana, B.	Zizyphus.
Family—*Chloropidæ*—	
Formosina flavipes, M.	Ginger and cardamon.
Chalcidomyia atricornis, M.	Ginger.

ORDER—DIPTERA—*cont.*

	Chief host plants.
Family—*Anthomyiidæ*—	
Atherigona oryzæ, M.	Paddy.
Atherigona indica, M.	Cholam.
Atherigona destructor, M.	Tenai.

ORDER—RHYNCHOTA.

Family—*Pentatomidæ*—	
Bagrada cruciferarum, F.	Cruciferous plants.
Coptosoma cribaria, Fb.	Pulses, lab-lab, agathi, etc.
Coptosoma ostensum, D.	Butea.
Coptosoma nazirae, At.	Cluster beans, mango, etc.
Stibaraopus tabulatus, F.	Tobacco.
Brachyplatys vahlii, F.	Agathi.
Vitellus orientalis, D.	Citrus plants.
Jurtina indica, D.	Pomegranate.
Tetroda histeroides, Fb.	Paddy.
Scotinophora lurida, B.	Do.
Cappaea taprobanensis, D.	Citrus plants on the hills.
Scutellara nobilis, F.	Phyllanthus.
Dolycoris indicus, S.	Cholam, redgram, etc.
Menida histrio, Fb.	Paddy.
Eusarcocoris guttiger, Th.	Cumbu.
Eusarcocoris ventralis, W.	Gingelly.
Antestia cruciata, F.	Coffee, jasmine.
Agonoscelis nubila, F.	Cholam, ani-seed.
Nezara viridula, L.	Cumbu, castor, potato, etc.
Cyclopelta siccifolia, W.	Erythrina, pongamia.
Piezodorus rubrofasciatus, F.	Cholam.
Aspongopus janus, F.	Cucurbitaceæ.
Aspongopus brunneus, N.	Do.
Halyomorpha picus, D.	Pomegranate.
Family—*Coreidae*—	
Anoplocnemis phasiana, F.	Cowpea, brinjal, etc.
Leptocorisa acuta, Th.	Paddy.
Clavigralla horrens, D.	Pulses.
Clavigralla gibbosa, S.	Do.
Riptortus pedestris, F.	Do.
Riptortus linearis, F.	Do.
Dasynus antennatus, K.	Orange.
Family—*Lygaeidæ*—	
Nysius inconspicuous, D.	Gingelly.
Oxycarenus lœtus, K.	Cotton, gogu.
Aphanus sordidus, F.	Groundnut, cumbu.
Family—*Pyrrhocoridæ*—	
Dysdercus cingulatus, Fb.	Cotton, gogu, etc.

ORDER—RHYNCHOTA—*cont.*

	Chief host plants.
Family—*Tingididæ*—	
Urentius echinus, D.	Brinjal.
Stephanitis typicus, D.	Turmeric, plantain.
Monanthia globulifera, W.	Tulsi (*Ocimum*) and safflower.
Leptopharsa ayyari, D.	Jasmine and artemesia.
Family—*Capsidæ*—(*Miriidae*)—	
Calocoris angustatus, L.	Cholam, maize.
Megacoelum stramineum, W.	Cholam.
Helopeltis antonii, Sign	Tea, cashew, guava.
Disphinctus politus, W.	Betel-vine.
Prodromus subviridis, D.	Banana.
Disphinctus humeralis, W.	Tea, cinchona.
Engytatus tenuis, R.	Tobacco, tomato.
Ragmus importunitas, D.	Sunnhemp.
Family-*Fulgoridæ*—	
Eurybrachys tomentosa, F. ..	Calotropis.
Pyrilla perpusilla, W.	Sugarcane.
Ricania bicolorata, D.	Coffee.
Perigrinus maidis, Dt.	Cholam, Maize.
Nysia atrovenosa, L.	Paddy.
Erythroneura subrufa, M.	Do.
Nilaparvata sordescens, M.	Do.
Purohita nigripes, D.	Bamboo.
Assamia moesta, W.	Sugarcane.
Family—*Cercopidæ*—	
Cosmoscarta relata, D.	Jak.
Phymatostetha deschampsi, L.	Plantain.
Clovia lineaticollis, D.	Jak.
Ptyelus *sp.*	Do.
Machaerota planitae	Zizyphus.
Family—*Jassidæ*—	
Idiocerus niveosparsus, L.	Mango, sapota.
I. clypealis, L.	Do.
I. atkinsoni, L.	Do.
Tettigoniella spectra, D.	Paddy.
Nephotettix bipunctatus, F.	Do.
Empoasca flavescens, F.	Castor, tea.
Empoasca devastens, D.	Cotton.
Deltocephalus dorsalis, M.	Paddy.
Family—*Psyllidæ*—	
Arytaina punctipennis, S.	Indigo.
Diaphorina citri, K.	Murrayia and citrus
Trioza *sp.*	Eugenia.
Pauropsylla depressa, Cr.	Cinnamon, ficus.

ORDER—RHYNCHOTA—*cont.*

	Chief host plants.
Family—*Aleyrodidæ*—	
Aleurolobus barodensis, W.	Sugarcane.
Aleurocanthus spiniferus, Q.	Citrus.
Dialeurodes vulgaris, K.	Jasmine.
Dialeurodes eugeniae, M.	Eugenia.
D. citri, A.	Citrus.
Neomaskellia bergi, S.	Sugarcane.
Trialeurodes ricini, M.	Castor.
Siphonimus finitimus, S.	Pomegranate.
Family—*Aphididæ*—	
Aphis maidis, F.	Cholam.
Macrosiphum solidaginis, F.	Safflower.
M. rosaeformis, D.	Rose.
Toxoptera graminum, R.	Wheat.
Tetraneura hirsuta, B.	Ragi.
Myzus persicae, S.	Tobacco and cruciferæ,
Tetraneura ulmi, K. coimbatorensis, G.	Sugarcane.
Aphis gossypii, G.	Cotton.
Greenidea artocarpi, W.	Jak.
Aphis laburni, K.	Lab-lab.
Dilachnus krishni, G.	Pear.
Eriosoma lanigera, H.	Apples, pears, etc.
Aphis tavaresi, D.	Citrus plants.
Aphis odinae, V. D.	Mango.
Oregama bambusae, B.	Bamboo.
Aphis malvae, K.	Cucurbits.
Aphis nerii, B.	Calotropis.
Pentalonia nigronervosa, Coq	Banana.
Setaphis bougainvillae, Th.	Phyllanthus.
Aphis rumicis, L.	Solanum nigrum.
Chermes *sp.*	Pine (Coonoor).
Aphis craccivora, K.	Pulses.
Family—*Coccidæ*—	
Orthezia insignis, D.	Lantana.
Icerya purchasi, M.	Citrus and wattles on the Nilgiris.
Icerya aegyptiaca, D.	Garden crotons, jak, Ficus
Aspidoproctus cinerea, Gr.	Pomegranate.
Aspidoproctus xyliæ, Gr.	Rain tree.
Monophlebus phyllanthi, Gr. ..	Garden crotons.
Ripersia oryzae, Gr.	Paddy.
Trionymus sacchari, Gr.	Sugarcane.
Phenacoccus hirsutus, Gr.	Teak shoots, Ficus.
Phenacoccus ornatus, Gr.	Jasmine.
Phenacoccus iceryoides, Gr.	Citrus, cotton, rain tree, etc.
Phenacoccus mangiferæ, Gr.	Mango.

ORDER—RHYNCHOTA—cont.

	Chief host plants.
Family—*Coccidæ*—cont.	
Centrococcus (**Phenacoccus**) **insolitus, Gr.**	Brinjal.
Pseudococcus bromeliæ, B.	Pine-apple.
Pseudococcus lilacinus, C.	Pomegranate, tamarind.
Pseudococcus corymbatus, Gr.	Jak, citrus.
Ferrisiana virgatus, C.	Crotons, tomato, cotton, etc.
Pseudococcus longispinus, T.	Coconut.
Pseudococcus citri, R.	Cocao, coffee.
Pseudococcus detorquens, G.	Bamboo.
Asterolecanium longum, G.	Do.
Cerococcus hibisci, G.	Cotton, garden Hibiscus, Tephrosia.
Anomalococcus indicus, G.	Acacia.
Dactylopius indicus, G.	Prickly-pear.
Aclerda japonica, N.	Sugarcane.
Lecanium discrepans, G.	Mango, banana.
Lecanium viride, Gr.	Coffee, citrus, bael, etc.
Lecanium adersi, N.	Mango.
Lecanium ramakrishnæ, Gr.	Ficus.
Lecanium depressum, C.	Crotons.
Lecanium longulum, D.	Redgram, grape.
Lecanium hesperidum, L.	Citrus, coconut.
Lecanium marsupiale, G.	Pepper (Coorg).
Saissetia oleæ, B.	Tamarind, Erythrina, fig.
Saissetia coffeæ, W.	Coffee, guava, ferns, tea, etc.
Saissetia nigra, N.	Cotton, Thespesia, Hibiscus *sp.*, croton, etc.
Ceroplastodes cajani, M.	Redgram, tulsi, zizyphus.
Ceroplastes floridensis, C.	Cashew.
Ceroplastes actiniformis, Gr.	Coconut, calophyllum.
Vinsonia stellifera, W.	Do.
Pulvinaria maxima, Gr.	Nim, cotton.
Pulvinaria psidii, M.	Guava, citrus, mango, etc.
Parlatoria zizyphus, L.	Citrus.
Parlatoria camelliæ, Cr.	Nim.
Lepidosaphes meliæ, Gr.	Do.
Lepidosaphes becki, Newst	Orange on the Nilgiris.
Lepidosaphes cornutus Green (M.S.) ..	Betel vine.
Lepidosaphes piperis, Gr.	Pepper.
Aspidiotus hartii, C.	Turmeric, yam.
Aspidiotus triglandulosus, Gr.	Jak.
Aspidiotus ficus, A.	Citrus, coconut.
Aspidiotus aurantii, M.	Rose, jasmine, citrus.
Aspidiotus tamarindi, Gr.	Tamarind.
Aspidiotus cydoniæ, C.	Grape.
Aspidiotus camelliæ, S.	Tea.
Aspidiotus lataniae, J.	Grape.
Aspidiotus orientalis, N.	Tamarind.

ORDER—RHYNCHOTA—*cont.*

	Chief host plants.
Family—*Coccidæ*—cont.	
Aspidiotus cyanophylli, S.	Plantain.
Aspidiotus destructor, S.	Coconut, plantain.
Pinnaspis aspidistræ, S.	Pepper, areca.
Chionaspis vitis, Gr.	Mango.
Chionaspis dilatata, Gr.	Areca, ferns.
Chionaspis elongata, G.	Bamboo.
Chionaspis herbæ, G.	Grass.
Chionaspis graminis, G.	Do.

ORDER—THYSANOPTERA.

Family—*Thripidæ*—	
Selenothrips rubrocinctus, G.	Cashew.
Dendrothrips bisninosus, B.	Tea.
Scirtothrips dorsalis, H.	Chillies.
Rhipihorothrips cruentatus, H.	Grape-vine, rose, etc.
Heliothrips haemorrhoidalis, B.	Garden crotons.
Ayyaria chaetophora, K.	Lab-lab.
Heliothrips kadaliphila, R.	Banana.
Heliothrips indicus, B.	Groundnut, onions, etc.
Taeniothrips distalis, Ky.	Lab-lab and other pulses.
Isoneurothrips orientalis, B.	Jasmine, morinda.
Thrips oryzae, W.	Paddy.
Thrips nilgiriencis, R.	Citrus.
Thrips tabaci, L.	Onions, garlic, cotton.
Bregmatothrips ramakrishnae, B. ..	Sugarcane.
Panchaetothrips indicus, B.	Turmeric, arrowroot.
Taeniothrips cardamomi, R.	Cardamom.
Taeniothrips jonnaphila, R.	Cholam ears.
Family—*Phloeothripidæ*—	
Arrhenothrips ramakrishnae, H.	Mimusops.
Gigantothrips elegans, Z.	Ficus *spp.*
Leeuwenia karnyana, R.	Eugenia.
Haplothrips ramakrishnai, K.	**Chrysanthemum.**
Fulmekiola indica R and M.	Sugarcane.
Fulmekiola saccharicida R. and M. ..	Do.
Rhynchothrips raoensis, R.	Cashew.
Kleothrips subramanii, R.	Palmyra.

APPENDIX B.

ORDERS AND CHIEF FAMILIES OF INSECTS.

The following summary of the classification of insects is added with the idea that it may help the student in determining to some extent the exact position of an insect collected in the fields or noted in any collections. In the case of entomological workers it is also desirable that, when an insect is studied, it is classified at least into its family which generally includes members having features and habits more or less common ; and for all ordinary purposes such a knowledge will be found sufficient. The following arrangement has been adapted from different modern works on Systematic Entomology and, in doing so, some of the small and unimportant families, especially those which are not known to occur in South India, have been omitted. Families of economic importance in South India are printed in bold types. This appendix is practically a supplement to Chapter VI of the text.

CLASS INSECTA.

Sub-class A.—APTERYGOTA (Ametabola). *

(Primitive insects without wings ; undergo no metamorphosis in development.)

ORDER 1—THYSANURA (Silver-fish).

(With long antenna and anal cerci.)

Family *Lepismidae.*

ORDER 2—COLLEMBOLA (Spring tails).

(With short antenna and ventral abdominal apppendages.)

Sub-class B.—PTERYGOTA.

(Insects with wings or descended from winged forms, metamorphosis partial or complete.)

DIVISION I.—EXOPTERYGOTA OR HEMIMETABOLA

(With imperfect gradual metamorphosis in development and no pupal stage.)

ORDER 3—ORTHOPTERA.

(Forewings forming a thick and narrow tegmen covering membranous hind wing ; mouth parts mandibulate—include cockroaches, grasshoppers, mantises, crickets, stick and leaf insects.)

Family—**Blattidæ** (Cockroaches).
Mantidæ (Mantises—predatory).
Phasmidæ (Leaf and stick insects).
Acrididæ (Grasshoppers, locusts—short horned).
Tettigonidæ (Grasshoppers—long horned).
Gryllidæ (Crickets).

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* A third order *Protura* generally brought under this group is given separate status as class : Myrintomata Order—Protura, by some recent workers.

ORDER 4—DERMAPTERA.

(Forewings very short, hind wings large and membranous, mouth parts mandibulate, abdomen with forceps—includes Ear-wigs.)

Family—**Forficulidæ.**
Labiidae.
Labiduridae.

ORDER 5—THYSANOPTERA (Physopoda).

Very small narrow bodied insects with fringes along sides of wings—flower visitors—plant gall makers—Thrips).

Family—Aeolothripidæ.
Thripidæ.
Phloeothripidæ.
Idolothripidae.

ORDER 6—HEMIPTERA (RHYNCHOTA).

(With sucking or piercing mouth parts—forewings half horny and half membranous—front of head not touching coxæ—tarsi usually with three joints—stink bugs, lace-wing bugs, aquatic bugs, etc.).

GROUP—GYMNOCERATA.

(Antenna conspicuous—Land forms.)

Family—**Pentatomidæ** (Stink bugs).
Coreidæ.
Berytidæ
Lygaeidæ
Pyrrhocoreidæ.
Reduviidæ (Assasin bugs).
Henicocephalidæ.
Saldidæ.
Tingidæ. (Lace-wing bugs).
Aradidæ.
Phymatidæ.
Capsidæ or Miriidæ (Mosquito bugs).
Cimicidæ (Bed bugs).
Anthocoridæ.
Ceratocombidæ.
Hebridæ.
Hydrometridæ (Aquatic).

GROUP—CRYPTOCERATA.

(Antenna small and hidden—aquatic forms.)

(Water bugs, water boatmen, water scorpions, **etc.**)

Family—Pelogonidæ.
Naucoridæ.
Belostomatidæ.
Nepidæ.
Notonectidæ.
Corixidæ.

ORDER 7—HOMOPTERA.

(With sucking or piercing mouth parts, two pairs of wings more or less equal and folded roof like over the body—front of head touches the coxæ—tarsi with one to three joints—Cicadas, Leaf hoppers, Spittle bugs, Plant lice, Scales, Mealy bugs, Mealy wings, etc., etc.)

Family—Cicadidæ (Noisy bugs).
Fulgoridæ.
Membracidæ (Cow bugs).
Cercopidæ (Spittle bugs).
Jassidæ (Leaf hoppers).
Psyllidæ (Jumping bugs).
Aphididæ (Plant lice).
Aleurodidæ (Mealy wings).
Coccidæ (Scales and mealy bugs).

ORDER 8—ANOPLURA.

(Wingless small flat insects—parasites on higher animals.)

Family—Pediculidæ (Human lice.)
Hematopinidæ (Cattle lice.)

ORDER 9—ISOPTERA.

(Both sexes with long wings which are soon shed—soft bodied biting mouth parts—social insects—White ants.)

Family—Termitidæ (Metatermitidæ).
Calotermitidæ.

ORDER 10—MALLOPHAGA.

(Wingless insects with flat large head and biting mouth parts—parasites on birds—Bird lice.)

Family—Gyropidæ.
Trichodectidæ.

ORDER 11—ODONATA.

(With long body and four equal wings with numerous nerves and biting mouth parts—larva aquatic—Dragon flies and Damsel flies.)

Family—Libellulidæ.
Aeschnidæ.
Agrionidæ.

ORDER 12—EMBIOPTERA.

(Small delicate insects living in silken tubes.)

Family—Embidæ.

ORDER 13—PSOCOPTERA (=Corrodentia)

(Wings membranous with the front ones larger; minute very delicate insects—often wingless—Book lice, bark lice, Death watches, etc.)

Family—Psocidæ (includes some subdivisions).

ORDER 14—PLECOPTERA.

(Semi-aquatic slow flying creatures—wings unequal—Stone flies.)

Family—Perlidæ.

ORDER 15—EPHEMEROPTERA.

(Delicate short lived insects with aquatic larvæ—hind wings greatly reduced and with long tail filaments and no mouth parts—delicate —May flies.)

Family—Ephemeridæ and others.

DIVISION II.—HOLOMETABOLA.

(With complete metamorphosis—a pupa present.)

ORDER 16—NEUROPTERA.

(Forewings equal and membranous with complex venation—biting mouth parts—some larvæ aquatic with gills on abdomen—Ant lions. Lace-wing flies, Mantis flies, etc.)

Family—Myrmeleontidæ (Ant lions).
Ascalaphidæ.
Mantispidæ.
Nemopteridæ.
Hemerobidæ.
Chrysopidæ (Lace-wings).
Coniopterygidæ.

ORDER 17—MECOPTERA.

(Head pointed forwards and with long narrow wings—mandibles strong—Scorpion flies.)

Family—Panorpidæ. (Predaceous insects).

ORDER 18—TRICHOPTERA.

(Very small insects; Wings moth like covered with hairs; with long feelers and reduced mouth parts—larva aquatic inside a case—Caddis flies.).

Family—Phryganeidæ.

ORDER 19—COLEOPTERA.

(Forewing forms a hard sheath (elytra)—to cover the really functioning hind wings—biting mouth parts—complete metamorphosis—Beetles.)

Sub-order A—**Adephaga.**

(Antenna filiform—tarsi generally five-jointed.)

Family—Cicindelidae (Tiger beetles).
Carabidæ (Ground beetles).
Dytiscidæ (Water beetles).
Gyrinidæ (Whirling beetles).
Paussidæ.
Rhysodidæ.

ORDER 19—COLEOPTERA—*cont.*

Sub-order B—**Polyphaga.**

(Antenna and tarsal joints variable.)

Family—Staphylinidæ.
Pselaphidæ.
Histeridæ.
Silphidæ (Burying beetles).
Nitidulidæ.
Trogositidæ.
Cucujidæ.
Erotylidæ.
Coccinellidæ (Ladybird beetles).
Endomychidæ.
Dermestidæ (Wooly bear beetles.)
Bostrychidæ.
Dascillidæ.
Byrrhidæ.
Ptinidæ (Anobidæ).
Cleridæ.
Cantharidæ
Malocodermidæ (Glow-worm beetles).
Hydrophilidae (water beetles).
Lyctidæ.
Buprestidæ (Jewel beetles).
Elateridæ (Click beetles).
Tenebrionidæ.
Cistelidæ.
Mordellidæ.
Meloidæ (Blister beetles—Cantharidæ).
Trictenotomidæ.
Anthicidæ.
Bruchidæ (Pulse beetles).
Chrysomelidæ (Leaf beetles).
Cerambycidæ (Longicorn beetles).
Curculionidæ (Weevils).
Anthribidæ.
Scolytidæ (Shot-hole borers).
Brenthidæ.

Sub-order C—**Lamellicornia.**

(Antenna leaf-like or lamellate at tip.)

Family—Passalidæ.

Lucanidæ (Stag beetles).
Scarabaeidæ (Chafer beetles).

ORDER 20—STREPSIPTERA.

(Very minute insects—males winged with the hind wing very large and front wings reduced antennæ flabellate—female degenerate vermiform attached to host—parastic—popularly known as Stylops—found on wasps, crickets, leaf-hoppers, etc.)

Family—Xenidæ (*Stylopidæ*).
Halictophagidæ.

ORDER 21—LEPIDOPTERA.

(Body and wings covered with dust like scales—wings large—mouth parts in the form of a rolled-up spiral proboscis—larva—a caterpillar—Butterflies and moths.)

Sub-order A—**Rhopalocera.**

(Day flying creatures—antennæ knobbed towards tip, wings erect when at rest—Butterflies.)

Family—**Nymphalidæ.**
Pieridæ (Whites).
Lycaenidæ (Blues).
Papilonidæ (Swallow tails).
Hesperiidæ (Skippers).

Sub-order B—**Heterocera.**

(Mostly nocturnal insects—antenna not knobbed—wings spread out, or overlapping abdomen when at rest—Moths.)

Family—Syntomidæ.
Arctiadæ (Hairy caterpillar moths).
Agaristidæ.
Noctuidæ.
Lymantridæ (Tussock moths).
Hypsidæ.
Sphingidæ (Hawk moths).
Eupterotidæ.
Notodontidæ.
Geometridæ (Loopers).
Saturnidæ (Wild silk moths).
Bombycidæ (Silk moths).
Lasiocampidæ.
Psychidæ (Bag worms).
Cochlididæ (Slugs).
Arbelidæ.
Cossidæ (Goat moths).
Zygænidae.
Pyralidæ.
Pterophoridæ (Plume moths).
Tortricidæ.
Carposinidæ.
Eucosmidæ.
Cosmopterygidæ.
Gelechiadæ.
Oecophoridæ.
Xyloryctidæ.

ORDER 21—LEPIDOPTERA—*cont.*

Sub-order B—**Heterocera**—*cont.*

Family—**Heliodinidæ.**
Glyphiterygidæ.
Hypnomeutidæ.
Gracillaridæ.
Plutellidæ.
Lyonetiadæ.
Tineidae.
Hepialidæ.

ORDER 22—DIPTERA.

(Two-winged insects—hind wings reduced to small halteres—mouth parts piercing or sucking—Flies.)

Sub-order A—**Nematocera.**

(Slender delicate flies with long antenna of more than six joints—larva with distinct head.)

Family—**Psychodidæ** (Moth and Sand flies).
Chironomidæ (Gnats and midges).
Culicidæ (Mosquitoes).
Dixidæ.
Blepharoceridæ.
Tipulidæ (Crane flies).
Cecidomyidæ (Gall flies).
Simulidæ (Black flies).
Bibionidæ.
Mycetophilidæ (Fungus gnats).

Sub-order B—**Brachycera.**

(**Flies with** small antennae of six or less than six joints—pupa like that of moths not enclosed in larval skin—no frontal lunule present—larva with incomplete head.)

Family—**Tabanidæ** (Gad flies).
Leptidæ.
Stratiomyidæ.
Bombylidæ (Bee flies).
Asilidæ (Robber flies).
Therevidæ.
Empidæ.
Dolichopidæ.

Sub-order C—**Cyclorrhapha.**

(**Pupa** enclosed in hard larval skin which forms an oval **hard** puparium—larva with vestigial head.)

Sub-group—**Aschiza.**

Family—Platypezide.
Phoridæ.
Pipunculidæ.
Syrphidae (Hover flies).
Conopidæ.

ORDER 22—DIPTERA—*cont.*

Sub-order C—**Cyclorrhapha**—*cont.*

Sub-group—**Schizophora.**

Family—Diopsidæ.
Celyphidæ.
Sepsidæ.
Cordyluridæ.
Micropezidæ.
Agromyzidœ.
Trypaneidœ (Fruit flies).
Drosophilidæ.
Ortalidæ.
Borboridæ.
Muscidaə (House and biting flies).
Anthomyiidæ.
Chloropidæ.
Sarcophagidœ (Flesh flies).
Oestridœ (Bot and warble flies).
Tachinidœ (Parasitic flies).

Sub-group—**Pupipara.**

Family—**Hippoboscidœ** (Cattle flies).
Streblidæ, Nycteribiidæ } (Bat flies).
Braulidæ (Bee parasites).

ORDER 23—SIPHONAPTERA (= Aphaniptera).

(Small laterally compressed active wingless insects—legs adapted for jumping—parasitic on higher animals—Fleas.)

Family—Pulicidæ.

ORDER 24—HYMENOPTERA.

(Wings membranous but with fewer cells, front wings larger than hind wings, biting and lapping mouth parts combined—Saw flies, wasps, bees and ants.)

Sub-order A—**Chalastogastra** (Symphyta).

(Abdomen and thorax broadly connected, trochanters of two joints—larvæ plant feeding and with legs.)

Family—**Tenthredinidæ** (Saw flies).
Siricidæ (Wood borers).
Xiphyidriidæ (Wood borers).
Orissidæ (Parasitic wood wasps).

Sub-order B—**Clistogastra** (Apocrita).

(Second segment of abdomen narrowed to form a stalk or petiole. trochanters of one or two joints—larva a foot less grub.)

Family—Cynipidæ (Gall wasps—now divided into three or four families.)
Serphoidea or Proctotrypidæ (now split up into half a dozen separate families).
Chalcidæ (has been now split up into over a dozen separate families).
Ichneumonidæ.
Braconidæ.

ORDER 24—HYMENOPTERA—*cont.*

Sub-order B—**Clistogastra** (Apocrita)—*cont.*

Family—**Evaniidæ.**
Alysiidæ.
Megalyridæ.
Stephanidæ.
Dryinidæ.
Bethylidæ.
Trigonalidæ.
Chrysididæ (Cuckoo wasps).
Mutillidæ (Velvet ants).
Scoliidæ.
Thynnidæ.
Psammocharidæ (Pompilidæ—Digger wasps, Potter wasps, etc., Solitary.)
Eumenidæ
Masaridæ.
Vespidæ (Hornets, Social wasps).
Sphegidæ (now broken up into a dozen separate families).
Apidæ (Bees—also broken up into many separate families).
Formicidæ (Ants).

Note.—Many of these wasp and bee families are now included under superfamilies like *Vespoidea*, *Sphecoidea*, *Apoidea*, *etc.*

APPENDIX C.

INSECT STUDY TECHNIQUE AND SOME USEFUL FORMULAE.

Insect collection and preservation.—Every student of Entomology will find it advantageous to make and maintain a collection of insects not only for studying at the moment but also for comparison with others in future. For, it is often found that some insects are found to appear in numbers only during certain seasons and never make their appearance for some years together; to provide for such a contingency an insect collection will be very useful. It will also be found that such a collection will be a very valuable asset for future workers. Fairly large and slow moving insects can be collected by hand, but active and flying creatures would require handnets and other appliances. Various special methods have nowadays been invented by specialists for the satisfactory collection of different kinds of insects but for all practical purposes, an ordinary cotton handnet will be found suitable. An ordinary handnet can be made of light thin cotton cloth or muslin fixed to a ring of cane or wire and attached on to the arms of a forked piece of wood (fig. 402);

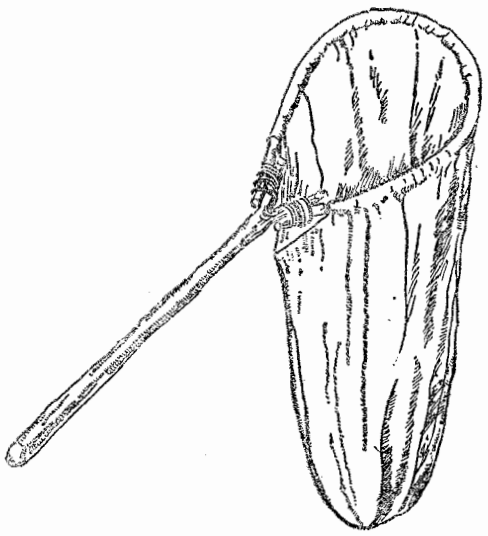

FIG. 402.—HAND NET.

[*From S.S.I.*]

with such a net most insects can be easily caught. Insects are also collected often with light traps, mechanical traps, sugar baits, etc. It may also be stated that among insects there are very few which are unsafe or risky to deal safely with the hands; these include a few poisonous caterpillars, some stinging hymenoptera and a few bugs which have a sharp piercing proboscis. Forms like sphingid caterpillars, big beetles, etc., though sometimes frightening in their appearance are quite harmless,

Collected insects are generally killed by dropping them into 'killing bottles' or vessels containing poison (for preparation of killing bottles see below).

The preparation and preservation of insects for a permanent collection depend upon the different kinds collected. All small and soft bodied forms like Aptera, some of the Neuroptera, plant lice and thrips are generally kept pickled in methylated spirit or formalin though some of them are specially prepared for microscopic study. The larvæ like caterpillars, beetle grubs, maggots, etc., may also be similarly preserved. Hard and large forms among beetles, grasshoppers, Hymenoptera, Rhynchota, flies, etc., are generally kept dry in insect boxes after mounting them with suitable sizes of pins. In the case of grasshoppers, beetles, and Heteroptera, the pins can be thrust through the right upper wing and left wing can be set broad if possible; in the case of Hymenoptera, Homoptera, Lepidoptera and flies, the pin may be put through the thorax and both wings set. Scales, mealy wings and mealy bugs are best preserved dry in envelopes with some naphthalene. Minute parasites can also be kept dry in small vials properly closed with a cork dipped in napnthalene solution. Some insects like ear-wigs and small beetles, bugs, flies and wasps can be gummed with shellac or beetle glue in slip of card or mica and the pins thrust through the card or mica piece; another method of preparing small forms is to attach them to small p ns and mount the latter on bits of pith. All dry preserved insects should be kept in properly dis'nfected insect proof boxes or containers; else they are liable to be damaged by small beetles and other museum pests.

It is very important that every insect in a collection should have a small label attached to it showing the date of collection, locality, the food plant, the initials of the collector and any special observations noted, and these labels should be as small as possible. Inside bottles or tubes containing pickled specimens such a label written in black lead pencil (not in ink or copying pencil) may be put in and if possible, an outside label pasted on to the bottle or tube. Insects without reliable labels serve no purpose in any collection; the information recorded in these small bits of paper will be found to be of very great value in due course not only to the collector himself but also for future workers who may handle such colle.tions.

Insect rearing.—Very often the earlier stages of insects like eggs, larvæ and pupæ are found in the fields; the collector will do well to have these bred out into adults so that he will not only be able to know what the insect is but will also get some idea of its earlier stages. This study will be found very interesting. There are hundreds of insects in all over India the early stages and life histories of which are yet unknown and such rearing when opportunities offer will considerably add to our knowledge. Though it is difficult to rear some forms in captivity, a good many insects breed and develop in artificial cages. Caterpillars and grubs of different kinds can be kept in perforated cardboard boxes or biscuit tins with plenty of thir food material covered over with a piece of thin cloth or muslin; small perforated zinc cages will also be found useful. Such of those larvæ which naturally pupate under ground will require some soil inside the cage and such of those which are acuatic in habits (like mosquitoes, water bugs, etc.), must be kept in that medium,

Preservation of the earlier stages of such insects will enhance the value of one's collections. In addition to the pickling of larvæ as described above, pupal cases and moulted skins are generally pinned dry with the adult to show that the insect has been reared from an earlier stage; the label of such an insect might also contain signs like E.L.P. to show that the insect was reared from an Egg, Larva or Pupa. In the case of many small insects and the portions of the bodies of larger ones, microscopic preparations are generally made and kept as permanent slides. The ordinary procedure in such cases is to dehydrate, clear and mount them on slides in Canada balsam; the details of such procedure, however differ with different insects and are not added here.

Suggestions for reporting insect damage.—When insects of any kind are found doing serious damage to crops in any area, the owners should lose no time in reporting the matter to an official Entomologist who, if he is convinced that the case is serious, will visit the locality himself or depute one of his men to investigate the same and do the needful. It is very important that the report should be sent as soon as possible; otherwise it becomes very late by the time any control measures are started and often the pest disappears by the time an officer or expert advice reaches the cultivator. As it is difficult and inadvisable to suggest remedies against the different kinds of insect pests without actual examination of the insects concerned in each case, it is necessary that along with the report, specimens of the insects found doing the damage or believed to do so may also be forwarded. The following directions may be followed in sending specimens of insects or insect affected materials: *Living specimens*—Live insects are always preferred to dead ones; this is especially so in the case of caterpillars, the soft worm like creatures which form the major group of our important crop pests; for, these are immature insects and have to be bred out into adults for correct identification. This may not be found possible when the parcel has to travel more than two or three days; in this case they may be forwarded killed and preserved as directed below. When sending live insects they may be despatched as far as possible under natural conditions. This can be done by placing them in perforated tin or cardboard boxes with a plentiful supply of food material which will last them for the journey. With regard to insects found boring into tree stems or branches, the portion of the stem containing the borer may be transmitted with the bore hole plugged. In cases where plant lice and scale insects affect plants, portions of the latter with the insects *in situ* may be packed in sheets of blotting paper and sent as a packet. Insects living under the soil may be sent with some moist earth in a box. *Dead specimens*—All soft insects like caterpillars, grubs, etc., may be sent preserved in bottles or jars of week spirits, whisky or country arrack; the bottle should be carefully packed in an outer case and forwarded. Hard insects like beetles, grasshoppers, etc., may be wrapped in paper and sent packed in saw dust or other packing material mixed with naphthalene or soaked in dilute Carbolic acid solution. Butterflies and moths should always be sent dry; this is done by folding the wings over the body and enclosing them flat in envelopes. In packing, the insects should never come into direct contact with cotton wool if this material is used for the purpose. It is advisable not to write the address over the parcel itself but attach a separate slip containing the address as this will reduce the chances of the parcel being smashed or jammed by the postal authorities.

It is also desirable that the parcel should be sent by the quickest method available so that live parcels may arrive quickly and in good condition. The parcels should contain the address of the sender also clearly, and it is better that they are sent unregistered as they arrive quicker in that case. The report connected with the parcel should contain as much information as possible on the following points :—

(1) Locality—
  (*a*) Village or villages affected.
  (*b*) Nearest railway station or town.
  (*c*) Taluk and district.
(2) Crop or crops affected.
(3) Vernacular names of insect, if any.
(4) Date of first notice of the pest.
(5) Nature of injury to crop.
(6) Extent of injury.
(7) Previous occurrence of the pest, if known.
(8) Local opinion and control measures adopted, if any.
(9) Any facts known regarding the life history and habits of insect.
(10) Any wild plant on which the insect is found to feed.
(11) Any natural enemies like birds, etc.
(12) Any other information available.

If the above instructions are followed it will be easy for an Entomologist to diagnose the particular insect damage and suggest suitable remedial methods with very little loss of time.

Some insect, collecting, preserving and control suggestions.

1. *Insect killing bottle*—

Cyanide of potassium	1 oz.
Plaster of Paris	4 oz.

Usually a wide-mouthed thick glass bottle with a tight fitting projecting cork which can be carried in one's pocket is used for this purpose. The bottom of the bottle is filled with lumps of Potassium cyanide and over this is sprinkled a liquid mixture of water and Plaster of Paris; the bottle is left open for the Plaster of Paris to dry, harden and cover the poison. When the surface has dried, two or three layers of blotting paper may be pressed over the surface and the bottle kept corked and properly labelled as *Poison*.

2. *Preserving fluid for larvae and soft insects*—

(*a*) Spirit mixture Alcohol 95 per cent ..	2 parts.
Glycerine	1 part.
Water	1 part.
Acetic acid	A few drops.
(*b*) Formalin Solution—	
Formaldehyde (40 per cent)	1 part.
Water	20 parts.

3. *Insect carding gum (Beetle glue)*—

Water	45 parts.
Alcohol (90 per cent)	8 parts.
Carbolic acid	2 parts.
Sugar	30 parts.
Gum arabic	60 parts.

4. *C.C.N. mixture to disinfect insect boxes*—

Chloroform	1 lb.
Naphthalene	¾ lb.
Creosote	2 lb.

Allow the powdered naphthalene to soak well in the chloroform and after a day, mix the creosote; shake well and keep bottle well corked. Brush insect boxes with this mixture as a disinfectant.

5. *Paraffin-naphthalene material for lining insect boxes*—

Paraffin of high melting point	15 oz.
Naphthalene	3 oz.

First varnish the box. Pour a little of the melted paraffin-naphthalene mixture on the floor of the box, fit in the cork sheet over it and pour more of the melted liquid over the cork sheet evenly. On drying it will present a beautiful white soft surface.

INSECTICIDES.

6. *Stomach insecticides*—

Lead arsenate powder for spraying	1 lb. with 50 gallons of water.
Lead arsenate paste for spraying	2 lb. in 50 gallons of water.
Lead arsenate powder for dusting	1 part to 8 parts hydrated lime.
Paris green for spraying	8 oz in 50 gallons of water.
Paris green for dusting	1 part to 15 parts of hydrated lime.
Calcium arsenate for spraying	1½ lb to 100 gallons of water.
Calcium arsenate for dusting	1 part to 5 parts of gypsum for vegetable leaf beetle.
Magnesium arsenate for spraying	1 lb. in 40 gallons of water.
Magnesium arsenate for dusting	1 part to 9 parts of hydrated lime.

Sodium fluroide, calcium fluroide, cryolite, calcium fluosilicate and Borax are also sometimes used as stomach insecticides.

For spraying the above mixtures some *spreaders* or *stickers* are used to make the sprayed liquid spread and remain on the plant surface. The usual materials used are Calcium caseinate flour paste, glue and even cactus juice.

7. *Contact insecticides*—

Kerosene emulsion—

Bar soap	8 oz.
Water	1 gallon.
Kerosene oil	2 gallons.

Dissolve the shavings of the soap in hot water. Remove the mixture from fire and slowly add the kerosene agitating the mixture to make it a good emulsion. For use, dilute one part of this stock solution with 15 to 20 parts of water useful against thrips, plant lice, etc.

Tobacco decoction—

Dry tobacco	1 lb.
Water	1 gallon.
Soap	4 oz.

Boil the tobacco in water for half an hour, strain this decoction, add the soap in shavings, heat well and cool. One part of this mixture is to be diluted with six or seven times its volume of water for spraying : a spreader like casein may also be used.

Nicotine spray—

Nicotine sulphate (40 per cent)	1 pint.
Water	125 gallons.
Soap	1 lb.

On a smaller scale one to two teaspoonfuls may be mixed in a gallon of water with a small quantity of soap.

Nicotine dust—

Nicotine sulphate	1 oz.
Hydrated lime	1 lb.

The two should be mixed throughly before dusting and the dust kept air-tight. Effective against plant lice.

Rosin wash—

Powdered rosin	10 lb.
Caustic soda	3 lb.
Fish oil	1½ lb.
Water	50 gallons.

Heat the rosin and fish oil in a gallon of water When the rosin has dissolved, add the caus ic soda dissolved in some water ; the mixture is thoroughly stirred and water added to make 50 gallons of spray liquid.

Lime sulphur—There are different formulae for this ; one of them is—

Stone lime	40 lb.
Sulphur	80 lb.
Water	50 gallons.

Slake the lime in about 10 gallons of water in a vessel ; when the slaking begins add the sulphur as a thin paste and stir the mixture well. Add water until the lime slakes thoroughly and bring it up to 55 gallons and then boil for half an hour and strain and store. For spraying, one part of this stock solution is mixed with 30 gallons of water.

8. *Grasshopper and cutworm bait*—

Paris green, white arsenic or soda arsenate.	1 lb.
Molasses or syrup	2 quarters.
Bran	25 lb.
Water	2·4 gallons.

A few drops of Amyl acetate or juice of a few crushed oranges may be mixed to the above for use against grasshoppers. Mix these into consistency of dough and make small pills for distribution in the haunts (5 lb of the bait will be sufficient for an acre).

9. *Repellents*—

Bordeaux mixture (3—5—50 receipe)

Copper sulphate	3 lb.
Hydrated lime	5 ,,
Cold water	50 gallons.

Dissolve the copper sulphate in a wooden or earthen tub of water. Slake separately the lime in water. Mix the two and make up to 50 gallons. For use against flea beetles, etc., 1 to 1½ lb. of lead arsenate can also be mixed with it with advantage.

10. *Ant baits*—

(*a*) Boil for half an hour—

Sugar	1¼ lb.
Water	1¼ pints.
Tartaric acid crystal	1 gram.
Benzoate of soda	1 ,,

(*b*) Dissolve ⅛ oz. of sodium arsenate in an ounce of hot water.

When (*a*) and (*b*) are cool, mix them and stir well. To this ½ lb. of strained honey may be mixed well. Small bits of sponge may be soaked in this solution and placed in ant haunts in small covered vessels with small holes for the ants to enter.

11. *Carbolic acid emulsion*—

Soap	1 lb.
Crude carbolic acid	1 pint.
Water	1 gallon.

Dissolve soap in hot water, add the carbolic acid and boil for twenty minutes. One part of this stock solution is to be mixed with twenty or twenty-five parts for use against ant nests, plant lice, mealy bugs, etc.

12. *Tar emulsion.*—Boil one pound of thin soap shavings in one pint of water and stir until they dissolve. Then add one pound of coal tar little by little stirring briskly all the while, till the whole thing becomes well mixed. This is the stock solution which can be diluted at a strength of half to one pound to every 10 gallons of water.

13. *Borer paste*—

Crude carbolic acid or phenyl	1 pint.
Soft soap	2 lb.
Hot water	1 gallon.

Dissolve soap in hot water and stir in the carbolic acid. Add ten gallons of water and sufficient clay to thicken it. This is to be used for plugging borer holes in fruit trees, etc.

14. *Fly paper*—

Rosin	5 lb.
Castor oil	3 pint.

Heat together until both mix well and become molasses like syrup. Paint this on any kind of paper with a brush and attach this fly paper on both sides of bits of cardboard and hang them.

15. *Fly poison*—

Formaldehyde (40 per cent)	3 teaspoonfuls.
Milk	1 pint.
Sugar or molasses	1 teaspoonful.
Water	½ pint.

A small bit of bread is placed in a shallow pan soaked in this mixture with a little of the liquid also and the pan is placed in the haunts of flies, taking care that children or domestic animals do not interfere with it, The vessel will have to be replenished frequently.

16. *Roachicide*—

Sodium fluoride	½ lb.
Flour	½ ,,

Dust the mixture in the haunts of cockroaches.

17. *Mosquito repellent*—

Citronella oil	1 oz.
Spirits of camphor	1 ,,
Oil of cedar	½ ,,

This mixture may be rubbed on the hands or a bath towel with a few drops sprinkled on it may be hung near the bed. Another effective culicide is *Camphor and Carbolic fume* prepared by evaporating equal parts of Camphor and Carbolic Crystals over a gentle heat (4 ounces for 1,000 cubic feet).

18. *Book solution*—

Carbolic acid	1 oz.
Corrosive sublimate	1 ,,
Methylated spirit	1 pint.
Liquid shellac	1 oz.

These are mixed well and painted with a brush on the bindings of books, frames of pictures, etc., which are attacked or likely to be attacked by book beetles, silver fish, etc. It is a poison and should be very carefully handled and stored.

19. *Fumigants*—

Carbon-bi-sulphide—

1 oz. to every 15 c.ft. of area enclosed. (4 lb. for 1,000 c.ft. area for 14 hours).

Hydrocyanic gas method—

Sodium cyanide	⅛ oz.
Water	½ fluid oz.
Commercial sulphuric acid	½ ,,

This will be sufficient for 1,000 c.ft. of space.

Calcium cyanide—

3 to 4 lb. of calcium cyanide dust will be sufficient for 1,000 c.ft. of space enclosed.

Tobacco fumigant—

3½ oz. of Nicofume tobacco powder is sufficient for 5,000 c.ft. of space enclosed.

P.D.B. (Paradichlorobenzene)—This is used as a soil fumigant; it is sold in the form of whitish volatile crystals.

BHC and DDT smoke canisters—These are used for fumigating granaries.

21. *Rat bait.*—Barium carbonate one part and flour three parts, make a dough of the two and into biscuits and coat them with paraffin.

WEIGHTS AND MEASURES.

Madras weights.

3 tolas	1 palam.
8 palams	1 seer.
5 seers	1 viss.
8 visses	1 maund.
20 maunds	1 candy.

Imperial Avoirdupois weight.

16 drachms	1 ounce (oz.).
16 oz.	1 pound (lb.).
14 lb	1 stone.
112 lb	1 hundred weight (cwt.).
20 cwt.	1 ton.

One Madras maund is 24.68 lb. (avoird.) and one pound (lb.) is 38.88 tolas.

5 fluid oz.	1 gill.
4 gills	1 pint.
2 pints	1 quart.
4 quarts	1 gallon.

One fluid ounce weighs one ounce, one pint of water weighs 1/5 lb. One gallon of water weighs 10 lb. The capacity of an ordinary kerosene tin is 4 gallons of fluid.

1 gramme (French unit of weight)	15.43 grains.
1,000 grammes (1 kilogramme)	2·20 lb.
1 ounce (28·35 grammes and 1 lb.)	453·58 grammes.
1 litre (35½ fl. oz., 1¾ pint, and 1 gallon)	4·54 litres.
25 millimetres (1 inch)	2½ centimetres (cm.).
1,000 millimetres (100 c.m.)	1 metre, 39·37 inches.
1,000 metres (1 kilometre)	1·609 English miles.
1 yard	0·914 metres.
1 sq. metre	10·764 sq. ft.
4,840 sq. yards (1 acre)	10 sq. chains.
640 acres	1 sq. mile.

An acre has roughly four equal sides of 70 yards (208·71 feet).
One acre = 4,840 sq. yds.

APPENDIX D.

NON-INSECT PESTS OF CROPS AND INSECTIVOROUS ANIMALS OF IMPORTANCE IN AGRICULTURE.

The following brief notes on some non-insect pests of crops and on forms which help us in controlling insect pests of different kinds are added with the idea that the information may be helpful since, very often enquiries are received by entomologists in connexion with the activities of such creatures though they are not insects. The following appear to be the more important of such animals :—

A. NON-INSECT PESTS OF CROPS.*

1. *Eelworms.*—These are very minute eel-like worms belonging to the division of animals known as round worms (*N. matehlminthes*) (fig. 403). There are numerous forms among these creatures which attack cultivated crops of different kinds and often cause serious damage. The chief damage caused by these animals consists in the worms attacking the rootlets of the plants and causing the characteristic knots or nodules in which the worms breed and the gradual fading and death of the whole plant. Infested plants when pulled out of the soil will reveal numerous nodules and when these are teased and examined under a microscope, the worms in different stages can be seen. The most notorious and widely distributed of these worms is the one known as the root gall-eelworm † (*Heterodera marioni, G.*). This has been noted on numerous crops all over the world, and in South India the most important ones subject to such attacks are pepper, betelvine, brinjal, tomato, tobacco, castor, rose, fig, jasmine, bhindi, tea, pulses of different kinds, turmeric, cucurbits, groundnuts and cruciferous plants like cabbage, cauliflower, mustard, etc.

Control.—It becomes a difficult problem to control the eelworm pest when the field is badly infested, since the pest remains in the soil even after the crop is harvested and is capable of reinfecting the next crop. Rotation of crops, proper disposal of crop remains after harvest keeping land fallow for a few seasons and the use of soil disinfectants are some of the well-known methods of control. According to Krishnan ‡ the treatment of soil with a mixture of Potassium cyanide and Ammonium sulphate may be useful "in eradicating soil nematodes under South Indian conditions".

2. *Snails and slugs.*—These creatures belong to the group of shelled animals (*Mollusca*). Though the great majority of these shelled animals are aquatic forms, snails and slugs live on land and are often found feeding on vegetation. Snails have an external spiral shell covering their soft body while slugs do not generally possess such a conspicuous shell. Though these are not regular pests, garden plants of different

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* *See* author's paper on 'Some animals (non-insect), of agricultural importance in South India'—1939, M.A J. XXVII (ii).

† This species has been recently placed under the genus Meloidogyne.

‡ Experiments on the Root gall Nematode in South India by P. N. Krishnan, Ind. J. Agr. Sc. III, 1933.

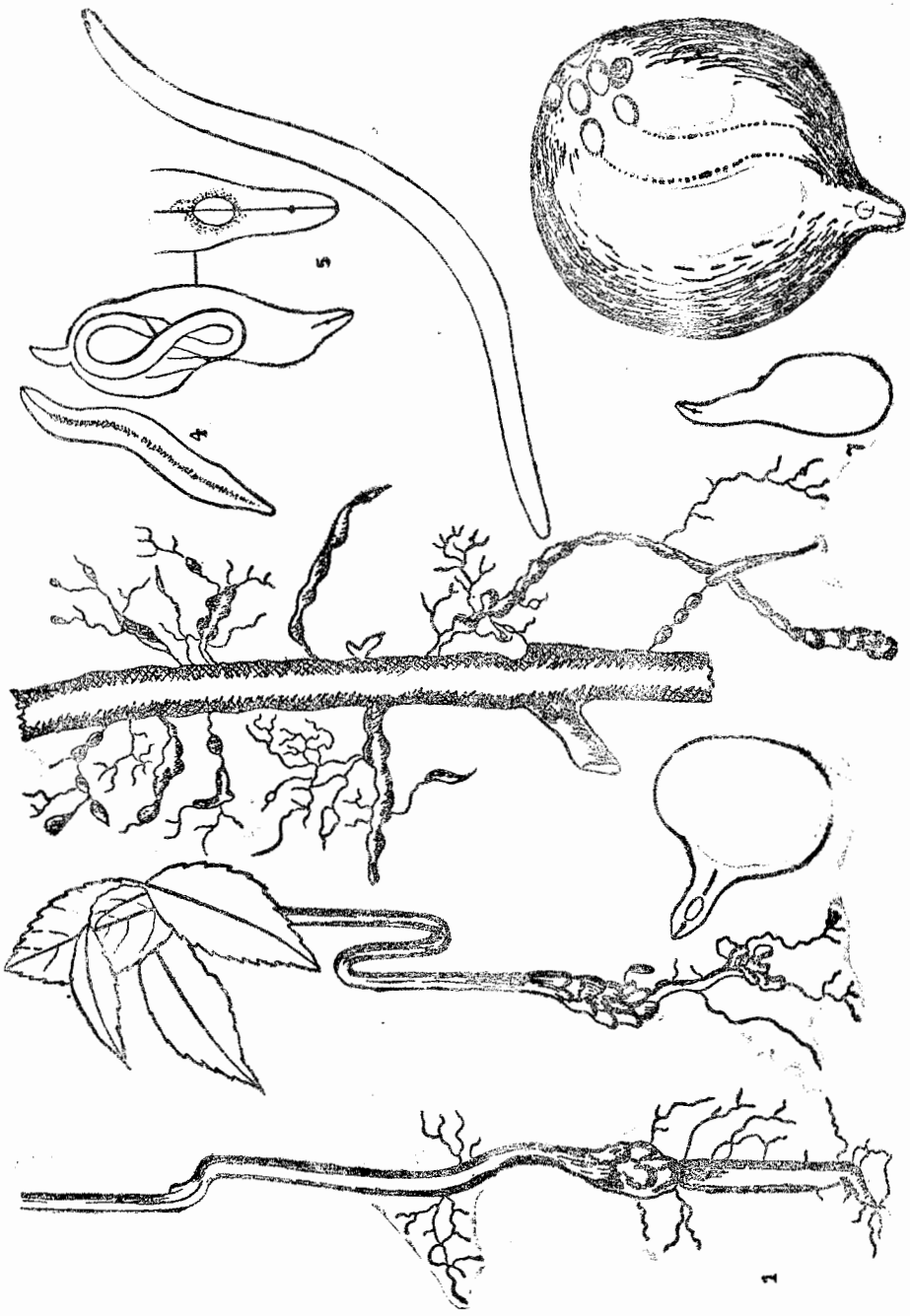

FIG. 403.—EELWORMS.

1 and 2 On tea.
3 On Cinchona.
4 to 6 Male worms (enlarged).
7 to 9 Female worms (enlarged).

[*After Barber*]

kinds are occasionally attacked by these creatures. Aloes are often found attacked by snails and holes are found bored on the succulent leaves. Slugs are now and then found in numbers in betelvine gardens occasionally nibbling agathi and betel leaves. On one or two occasions paddy seedlings were reported damaged by small snails in parts of the Kistna delta near Tenali. These creatures are evident during wet weather and in damp areas and are generally active during the night. During dry weather, snails may be found sealed fast to different plants and tree stems ; they revive and become active with the return of humid and wet conditions.

Control.—Generally their damage to plants has so far been negligible in South India. When found in numbers they may be checked by hand-picking and by the use of irritants and poison baits. The use of one part of calcium arsenate with sixteen parts of wheat bran mixed dry with enough water to make the stuff moist, scattered in the haunts of snails has been found effective against the garden snail in California. Spreading of lime, soot, wood ashes, etc., on the ground also acts as a deterrent against slugs.

3. *Crabs* [1] (*see* fig. 1).—These familiar creatures are Arthropoda and come under the group Crustacea in which are also included the prawns, lobsters, water fleas, etc. These have an oval body with ten conspicuous legs and the abdomen tucked under the thorax. Crabs have been noted to cause considerable damage during certain years to young paddy plants chiefly in the Cauvery delta. Though in food habits crabs are generally carnivorous, this plant-feeding habit has been noted in some of the fresh water crabs. During the time when the paddy crop is very young these creatures cut the tender plants at ground level and carry the pieces to their holes to be used as food , this is generally done during dusk or at night. The species of crab commonly noted as a pest in South India is *Paratelphusa hydrodromus*, H.

Control.—The control of this paddy fields crab is generally brought about by hand collecting of the crabs, baiting with poisoned food or by dropping the bait into the crab holes and trapping with crab pots-narrow mouthed earthen pots filled with attractive eatables and planted at the edge of the water channels.

4. *Mites.*[2]—These belong to the class Arachnida which includes the spiders, scorpions, ticks, etc. These are minute creatures with on oval or elongate oval body having eight legs. Different kinds are found attacking cultivated plants of various kinds. Colonies of them are found on plant tissue sucking up the plant sap and causing damage. Well known examples are the cholam mite (*Paratetranychus indicus*, H.), the citrus mite (*Tetranychus hindustanicus*. H.), the cotton mite (*Anychus latus*, C. and F.), the tea mite (*Tetranychus bioculatus*, W., fig. 404) and the castor and ganja mite (*Tetranychus telarius*, L.), the last one has a world wide distribution and has been noted on numerous plants, such as cotton, rose, fig., etc.

Control.—Application of flowers of sulphur or spraying with lime sulphur solution will be found effective against these creatures. Some of the plant feeding mites also produce galls on the plants.

1 Crabs as pests of Mico by C. C. Gosh—IIIrd Ent. Meet. Pusa P. 680, 1919.

2 *See* "Mite pests of crops in S. India by M. C. Cherian—Agr. Livestock VIII 1938.

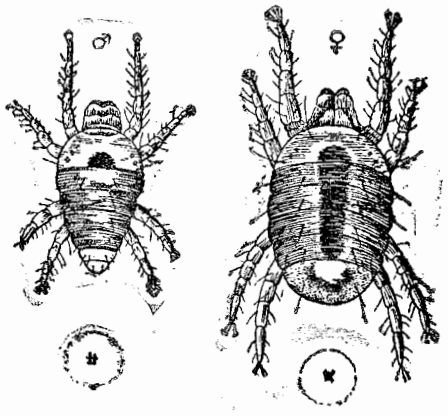

FIG. 404.—RED SPIDER ON TEA.
(*Tetranychus bioculatus. W.*)

[*From S.S.I.*]

This group also includes what are popularly known as ticks (Ixodidae) and other forms some of which are parasitic on warm blooded animals and often transmit different kinds of diseases.

5. *Millipedes.*—These thousand legged creatures are also Arthropods included under the group Myriapoda with the centipedes. The elongate cylindrical creatures are occasionally caught damaging roots of plants in vegetable gardens and damaging the underground pods of groundnuts in some areas.

Control.—They may be treated as for cutworms, whiteants and wire worms by such measures as use of poisoned baits, poisoning the irrigation water, etc.

6. *The Anaikuthu pambu.**—This animal is a creature occasionally noted injurious to paddy fields along different areas of the Coromandel coast. It is a long flat eel-fish (*Ophichthys boro,* H.) having the general appearance of a snake and lives in the tidal streams and estuaries along the coast. No direct harm is caused to the growing plants but only indirect damage by numbers of these eels burrowing into and making wide passages across the bunds, thus connecting the paddy fields containing fresh water on the one side and the adjacent salt water channels on the other. This causes salt water to get into the fields and affect the growing plants due to the ill effects of salt. Often this kind of damage is also done to salt pans in some of the coastal salt depots. The radical measure against these is to strengthen the bunds and prevent admission of the fish into the fields. They can also be trapped by mechanical methods and destroyed.

7. *Higher animals.*—Among higher animals often found doing damage to crops may be included rats, squirrels, rabbits, monkeys, flying foxes (*Pteropus*) and some graminivorous and fruit eating birds, among these, however, the most notorious are the rats. Among rats there are

* *See* Author's paper on this pest—J. B. N. H. Soc. XXXVI, 1932.

some which are field rats attacking crops like paddy, sugarcane, coconuts, etc., while there are others which are household and granary pests. According to Krishna n,* the most destructive and well-known of our field rats damaging crops are the mole rat (*Bandicota bengalensis* G.) the Indian Gerbill e (*Tatera cuvieri*, W.) (fig. 405), (the coconut attacking species—*Rattus rattus*, Bl., and the common house rat (*Rattus rufescens*, G.)

FIG. 405.—THE INDIAN GERBILLE RAT.
(*Tatera cuvieri*, W.)
[*After Blanford*]

Rat control—The usual rat control measures consist of poisoning by baits, by traps, and by fumigation of rat holes in field bunds. For the coconut tree rat tin bands or slopes may be fitted to prevent the creature ascending the tree (fig. 406). Among injurious birds, the omnivorous crow, the cosmopolitan house-sparrow, pigeons, parrots (fig. 40) of different kinds and some other grain and fruit eating birds which appear during certain seasons in the year are the most important of our bird pests and different methods including trapping, poisoning and shooting are employed to keep them in check. In addition to rats and the animals mentioned above, field crops in some tracts are often subject to the attacks of jackals, monkeys, † wild pigs, mungooses, palm cats, porcupines, bison and even elephants; especially is this the case in forest areas. Jackals are partial to sugarcane and wild pigs to

* Notes on rats damaging crops in S. India by P. N. Krishnan—J.B.N.H. Soc., XXXIV, 1931.

† Reference may be made to the author's paper on "Monkeys in relation to Agriculture" M.A.J. XXVI, 1938.

FIG. 406.—RAT PREVENTIVE BAND ON COCONUT TREE.

[*From S.S.I.*]

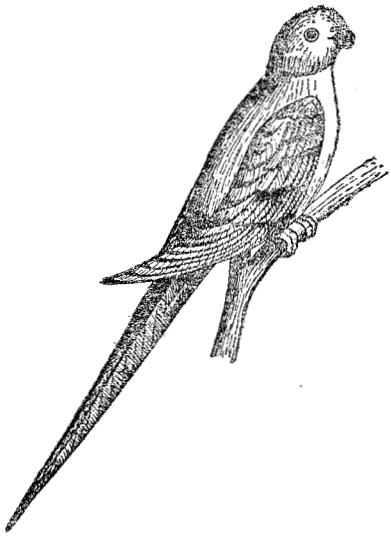

FIG. 407.—ROSE-RINGED PARROT.
(*Palaeornis torquatus.*)

[*After Cunningham*]

root crops (fig. 408). The control of these pests in the case of valuable crops like sugarcane can be effected by good fences, and in submontane areas where there is trouble with wild animals like elephants, bears, etc., they have to be kept in check by the creation of natural barriers like strong fences, ditches, etc., and even with the use of the hunter's gun.

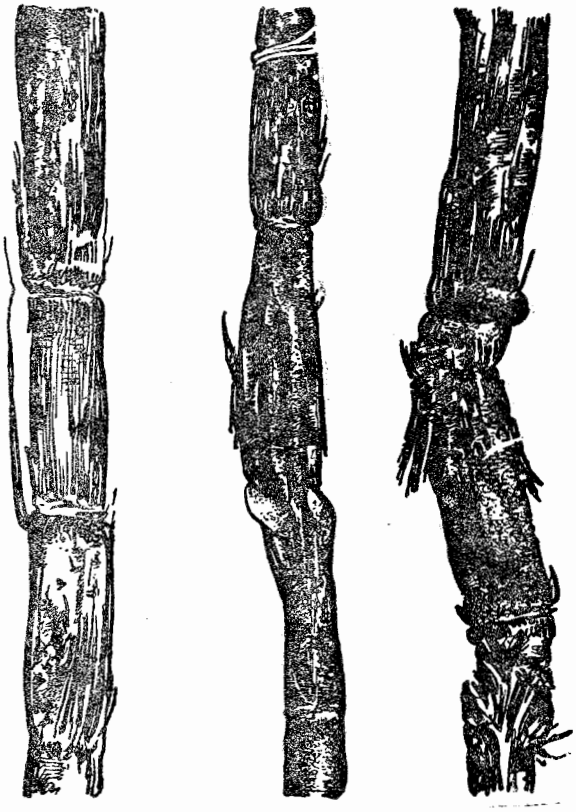

FIG. 408.—SUGARCANE DAMAGED BY JACKALS.

B. Insectivorous Animals.

As in the case of insect-feeding insects many of which help the farmer in controlling pests as parasites or predators, there are among non-insect animals also several forms which are insectivorous and which in many cases help considerably in checking insect pests. These include toads, lizards, birds, bats, bears, spiders, etc. The most important among insectivorous animals, however, belong to the group of birds though, as stated before, we have even among these, some which are notorious pests and some which take to both vegetable and insect food. Some of these insect feeding forms play the role of very efficient natural checks of insect pests of different kinds through some of these insectivorous birds like the bee-eater (*Merops viridis*) which causes injury by attacking the honey bee are also injurious. The most important of these insect-feeding birds, helpful to the farmer in the plains of

South India are the mynah, the king crow, the roller, the hoopoes, the wood pecker, the tailor bird, the bulbul, the fly catcher, the owl, the paddy bird, fowls, ducks and turkeys (figs. 409 to 412). Some of

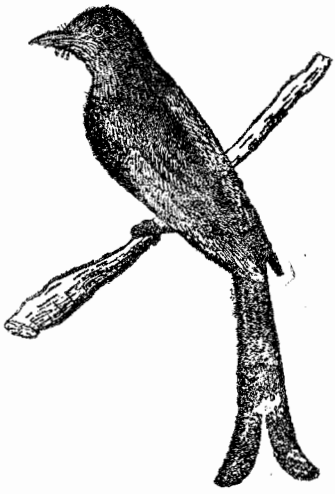

FIG. 409.—THE KING CROW.
(*Dicrurus ater.*)

[*From S.S.I.*]

FIG. 410.—THE MYNAH.
(*Acridotheres tristis.*)

[*From S.S.I.*]

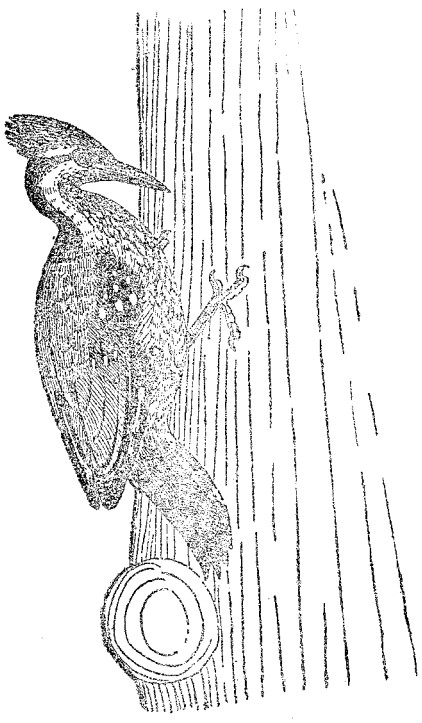

FIG. 411.—THE GOLDEN WOOD PECKER.
(*Brachypternus aurantius.*)

[*After Blanford*]

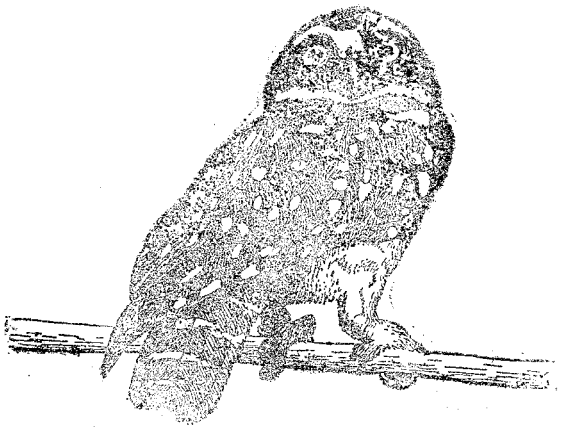

FIG. 412.—SPOTTED OWL.
(*Athene brama.*)

[*After Dewar*]

these birds voraciously feed on such injurious caterpillars and grasshoppers like the swarming caterpillar of paddy and allied cutworms, the castor semilooper, white grubs, grasshoppers, mango hopper, etc. The common crow is omnivorous and frequently a nuisance, but it often does good work as a scavenger and an insect eater (*see* fig. 413).

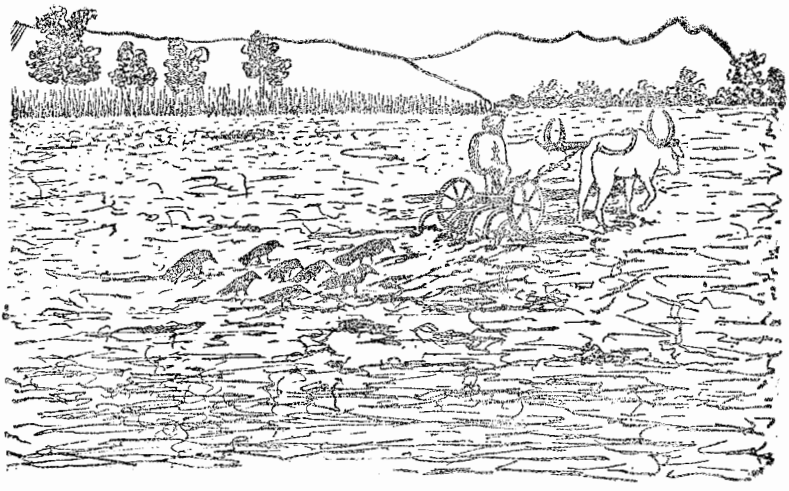

FIG. 413.—CROWS FOLLOWING THE PLOUGH FOR SOIL INSECTS.

[*From S.S.I.*]

The agriculturists will therefore do well to encourage these beneficial birds in all possible ways and not resort to the indiscriminate destruction of all birds either for sport or for food. In areas badly infested with pests, perches may be supplied to birds in different parts of the field and for aquatic birds like ducks, turkeys, etc., in wet lands plenty of water may be let in to help them do their work actively. Such encouragement of useful birds is effected in many countries both by legislative and direct measures, the former preventing the killing of certain birds during particular seasons and the latter by helping useful birds by giving them nesting places and protection from enemies in the vicinity of cultivated areas as stated above.

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